



US009422119B1

(12) **United States Patent**  
**Fortenbery et al.**

(10) **Patent No.:** **US 9,422,119 B1**  
(45) **Date of Patent:** **\*Aug. 23, 2016**

(54) **INDEPENDENT DISCHARGE SORTING  
CONVEYOR**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Mantissa Corporation**, Charlotte, NC  
(US)  
(72) Inventors: **J. David Fortenbery**, Charlotte, NC  
(US); **David Patrick Erceg**, Concord,  
NC (US); **Gonzalo Sotelo**, Charlotte,  
NC (US); **Charles P. Howell, III**,  
Charlotte, NC (US); **Gregory P. Kissel**,  
Charlotte, NC (US); **Daniel H.**  
**Weckerle**, Charlotte, NC (US); **LeRoy**  
**A. Winkler, III**, Charlotte, NC (US)

3,034,665 A	5/1962	Speaker
3,119,488 A	1/1964	Rabinow et al.
3,167,192 A	1/1965	Harrison et al.
3,211,279 A	10/1965	Smith
3,233,720 A	2/1966	Atanasoff et al.
3,265,190 A	8/1966	Boehm
3,270,860 A	9/1966	Siebach
3,510,014 A	5/1970	Speaker et al.
3,577,928 A	5/1971	Victorri et al. .... 104/148 LM

(Continued)

OTHER PUBLICATIONS

(73) Assignee: **Mantissa Corporation**, Charlotte, NC  
(US)

"Progress Reports, VDI, Row 13", German text, vol. 1998 vol. 47,  
pp. 16-51.

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.  
This patent is subject to a terminal dis-  
claimer.

(Continued)

*Primary Examiner* — Thomas Randazzo

(74) *Attorney, Agent, or Firm* — MacCord Mason PLLC

(21) Appl. No.: **14/330,611**

(22) Filed: **Jul. 14, 2014**

**Related U.S. Application Data**

(63) Continuation of application No. 13/529,584, filed on  
Jun. 21, 2012, now Pat. No. 8,807,320.

(51) **Int. Cl.**  
**B65G 47/96** (2006.01)  
**B65G 47/38** (2006.01)  
**B65G 17/12** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **B65G 47/38** (2013.01); **B65G 17/12**  
(2013.01); **B65G 47/962** (2013.01)

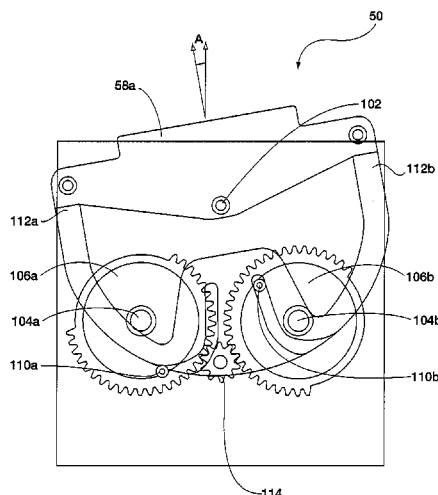
(58) **Field of Classification Search**  
CPC ..... B65G 47/38; B65G 17/12; B65G 47/962  
See application file for complete search history.

(57)

**ABSTRACT**

A sorting conveyor for transporting objects and unloading  
objects at one or more unloading stations adjacent the  
conveyor. The sorting conveyor includes a conveyor track  
and a train of conveyor carts connected end-to-end. At least  
one of the conveyor carts may include a frame base for  
engaging the conveyor track; a carrying tray for holding the  
objects; and a support for supporting the carrying tray above  
the frame base. A tilting mechanism including at least one  
gear having at least one cam is adapted for tilting the  
carrying tray toward at least one side of the conveyor. The  
present inventions may further include a tilt sensor for  
determining the direction of tilt of the tray. In addition, a  
drive motor and a driven member attached to the frame base  
may be included for moving the conveyor carts around the  
track.

**41 Claims, 25 Drawing Sheets**



(56)

**References Cited**

## U.S. PATENT DOCUMENTS

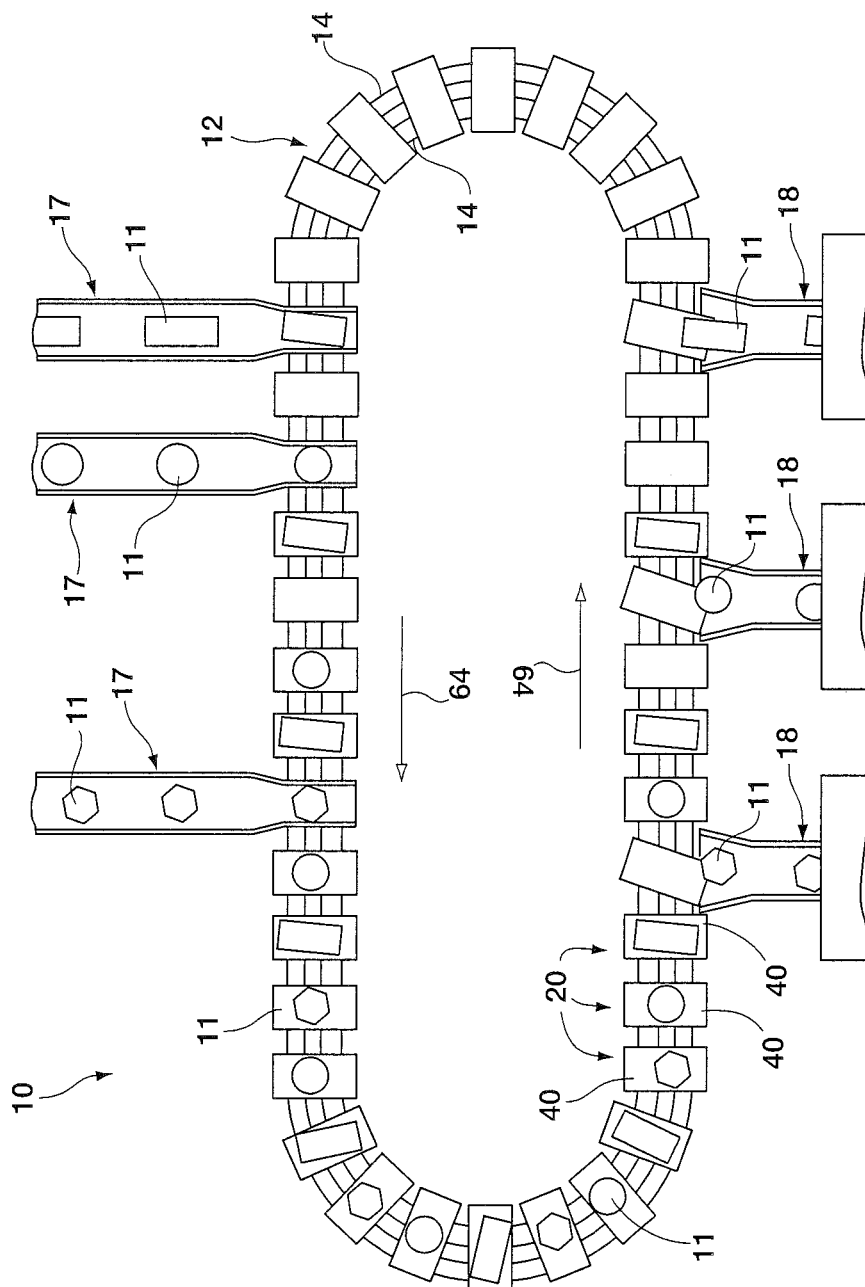
3,630,394 A 12/1971 Kingzett ..... 214/62 A  
 3,669,245 A 6/1972 Wooten et al. .... 198/155  
 3,749,025 A 7/1973 Giraud ..... 104/25  
 3,788,447 A 1/1974 Stephanoff ..... 193/41  
 3,834,316 A 9/1974 Hennings ..... 104/148 LM  
 3,848,728 A 11/1974 Leibrick et al. .... 198/155  
 3,881,609 A 5/1975 Ellis et al. .... 214/11 R  
 3,910,406 A 10/1975 Pulver et al. .... 198/189  
 3,945,485 A 3/1976 Speaker ..... 198/155  
 3,974,909 A \* 8/1976 Johnson ..... B65G 47/962  
 105/272  
 3,977,513 A 8/1976 Rushforth ..... 198/38  
 4,004,681 A 1/1977 Clewett et al. .... 198/796  
 4,031,998 A 6/1977 Suzuki et al. .... 198/365  
 4,102,448 A 7/1978 Wolbrink et al. .... 198/365  
 4,174,773 A 11/1979 Venzke ..... 198/365  
 4,197,933 A 4/1980 Dunstan et al. .... 198/334  
 4,413,721 A 11/1983 Bollier ..... 198/365  
 4,512,710 A 4/1985 Flatau ..... 414/735  
 4,635,785 A \* 1/1987 Prydtz ..... B65G 47/962  
 198/370.04  
 4,669,388 A 6/1987 Dehne et al. .... 104/162  
 4,726,464 A 2/1988 Canziani ..... 198/365  
 4,744,454 A 5/1988 Polling ..... 198/365  
 4,841,869 A 6/1989 Takeuchi et al. .... 104/292  
 4,846,335 A \* 7/1989 Hartlepp ..... B65G 47/962  
 198/370.04  
 4,848,242 A 7/1989 Matsuo ..... 104/290  
 4,856,642 A \* 8/1989 Nicholson ..... B65G 47/962  
 198/370.04  
 4,876,966 A 10/1989 Okawa et al. .... 104/290  
 4,919,054 A 4/1990 Matsuo ..... 104/94  
 4,982,828 A \* 1/1991 Nicolson ..... B65G 47/962  
 198/370.04  
 4,984,674 A \* 1/1991 Fortenberry ..... B65G 47/962  
 198/370.04  
 5,054,601 A 10/1991 Sjogren et al. .... 198/365  
 5,086,905 A \* 2/1992 Polling ..... B65G 47/96  
 198/370.03  
 5,176,485 A 1/1993 Ruder et al. .... 414/392  
 5,255,774 A \* 10/1993 Yokoya ..... B65G 47/962  
 198/370.03  
 5,271,492 A 12/1993 Lewin et al. .... 198/830  
 5,372,234 A \* 12/1994 Fortenbery ..... B65G 47/962  
 198/890.1

5,433,311 A \* 7/1995 Bonnet ..... B65G 17/345  
 198/370.04  
 5,664,660 A \* 9/1997 Prydtz ..... B65G 47/962  
 198/370.03  
 5,676,514 A \* 10/1997 Higman ..... B61B 13/04  
 198/349  
 5,836,436 A \* 11/1998 Fortenbery ..... B65G 11/023  
 198/370.03  
 5,894,918 A \* 4/1999 Bonnet ..... B65G 17/086  
 198/370.02  
 6,003,656 A \* 12/1999 Fortenbery ..... B65G 47/962  
 198/370.03  
 6,009,992 A \* 1/2000 Erceg ..... B65G 47/962  
 198/370.04  
 6,182,813 B1 2/2001 Bonnet ..... 198/370.09  
 6,239,744 B1 \* 5/2001 Singer ..... H01Q 1/246  
 342/359  
 6,246,023 B1 \* 6/2001 Kugle ..... B07C 5/36  
 104/290  
 6,298,975 B1 \* 10/2001 Fortenbery ..... B65G 47/38  
 104/284  
 6,367,610 B1 \* 4/2002 Fortenbery ..... B65G 47/962  
 198/370.03  
 6,382,392 B1 \* 5/2002 Fortenbery ..... B65G 47/962  
 198/370.03  
 6,502,687 B1 \* 1/2003 Ayen ..... B65G 47/962  
 198/370.04  
 6,736,254 B1 \* 5/2004 Fortenbery ..... B65G 47/962  
 198/370.03  
 6,959,803 B1 11/2005 Layne et al. .... 198/600  
 7,284,654 B2 \* 10/2007 Affaticati ..... B65G 47/962  
 198/370.04  
 8,069,976 B1 12/2011 Fortenbery et al. .... 198/860.1  
 8,851,267 B2 \* 10/2014 Sotelo ..... B65G 17/12  
 198/370.04  
 2013/0126304 A1 \* 5/2013 Stikkelorum ..... B65G 47/40  
 198/477.1  
 2013/0168300 A1 \* 7/2013 Malone ..... B07C 5/3412  
 209/583  
 2013/0341157 A1 12/2013 Fortenbery et al. .... 198/370.04  
 2015/0083549 A1 \* 3/2015 Ram ..... 198/358

## OTHER PUBLICATIONS

“Design and Composition of Drive Systems for Bulk Goods-Sorting Machines,” Engineering Process, Statistic Reports VDI, Row 13: Conveyor Technique/Logistics, No. 47, 1998.

\* cited by examiner



**FIG. 1**

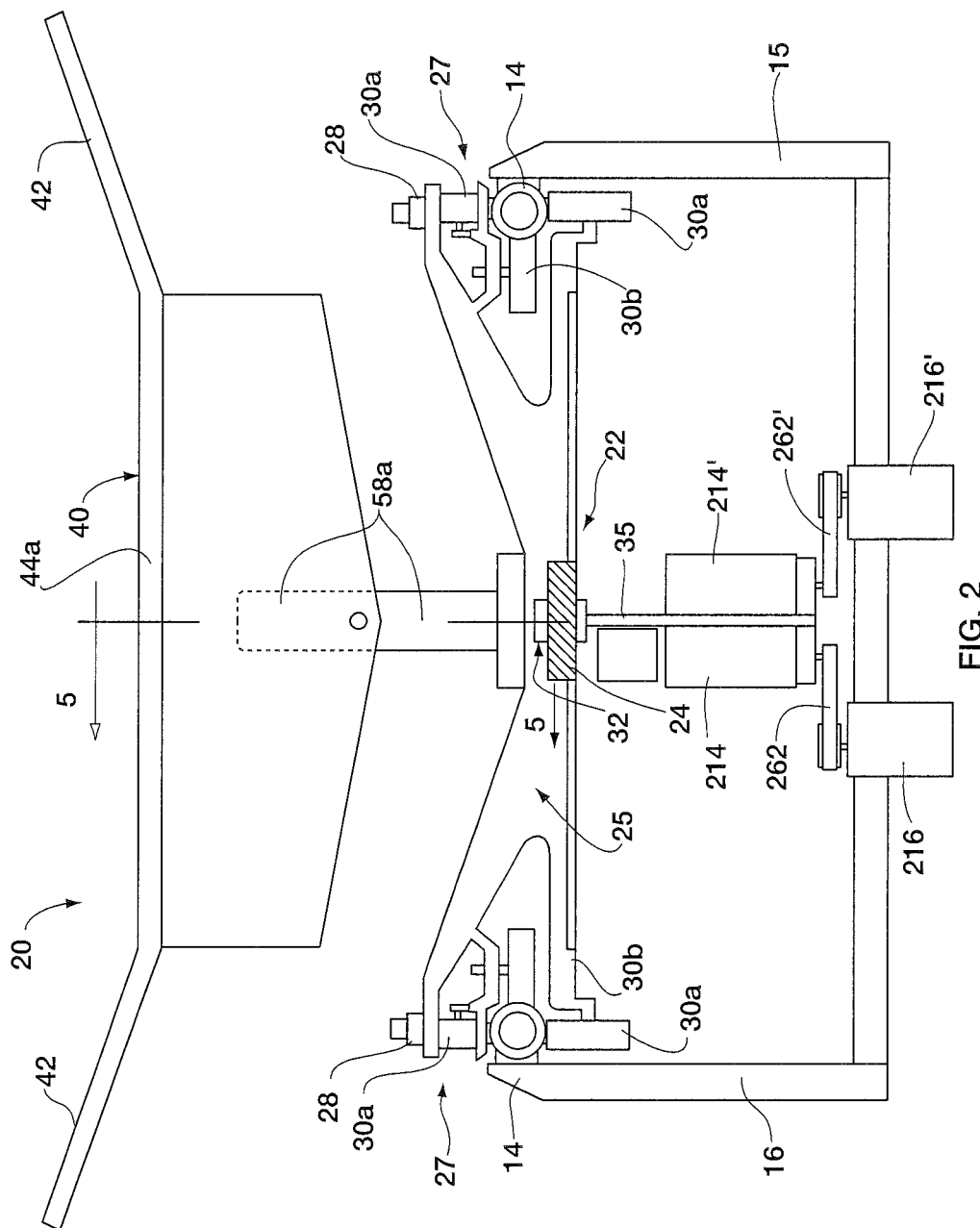


FIG. 2

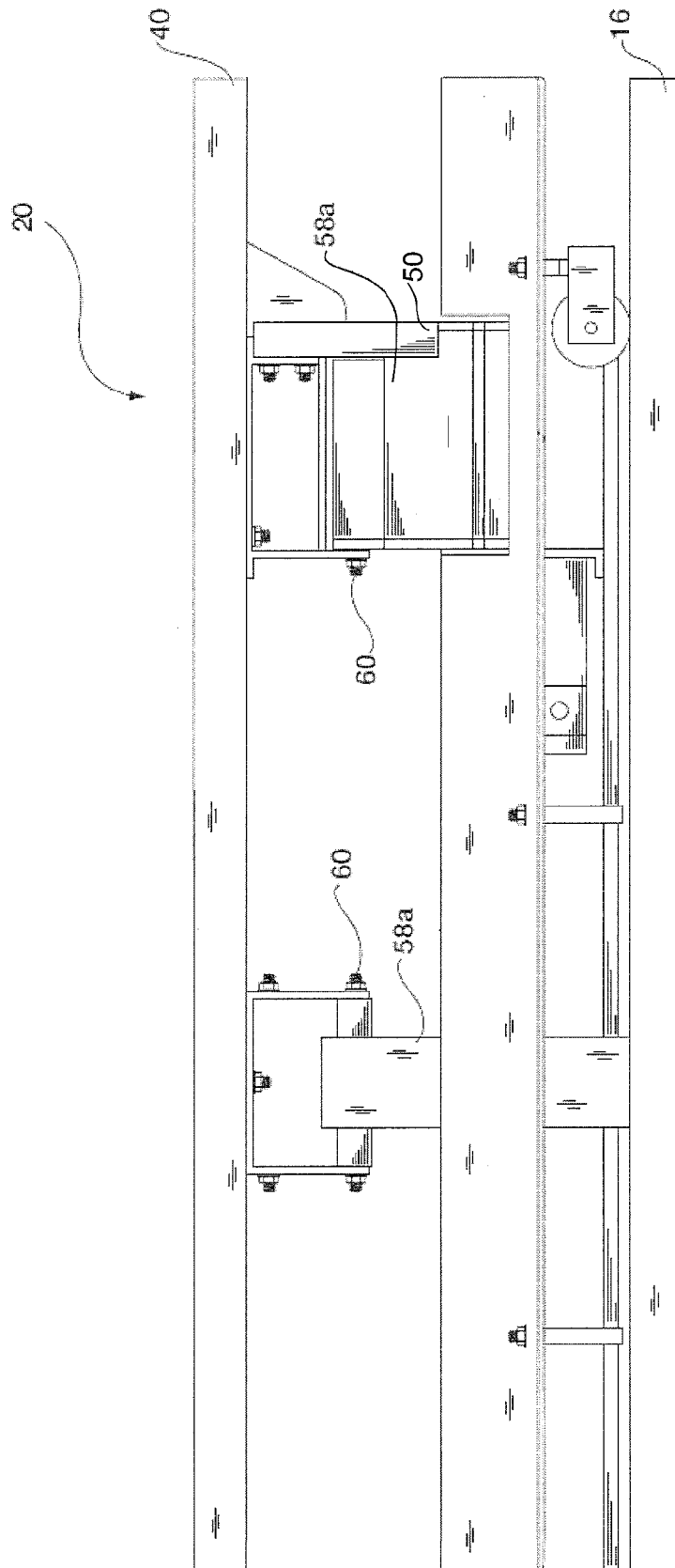
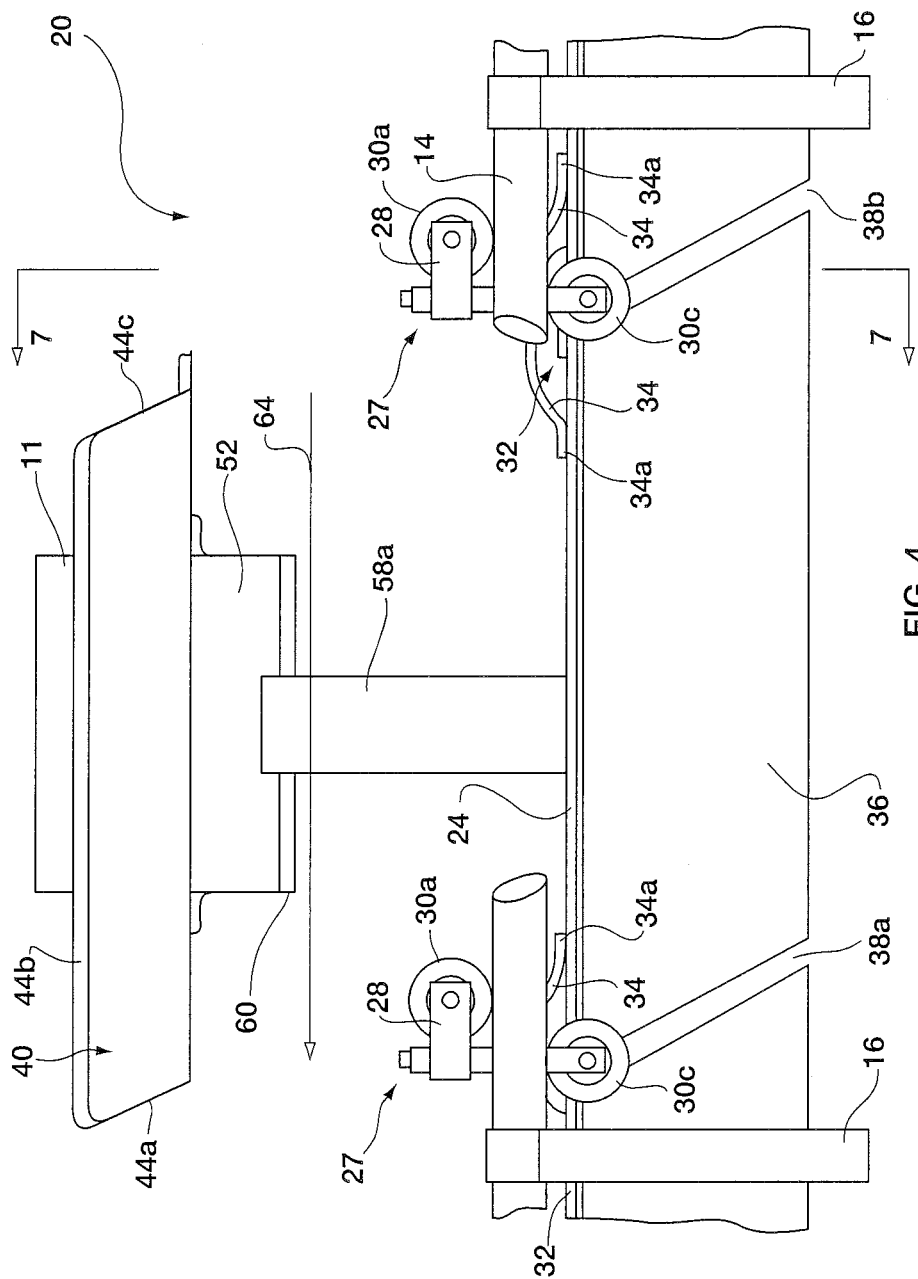


FIG. 3



**FIG. 4**

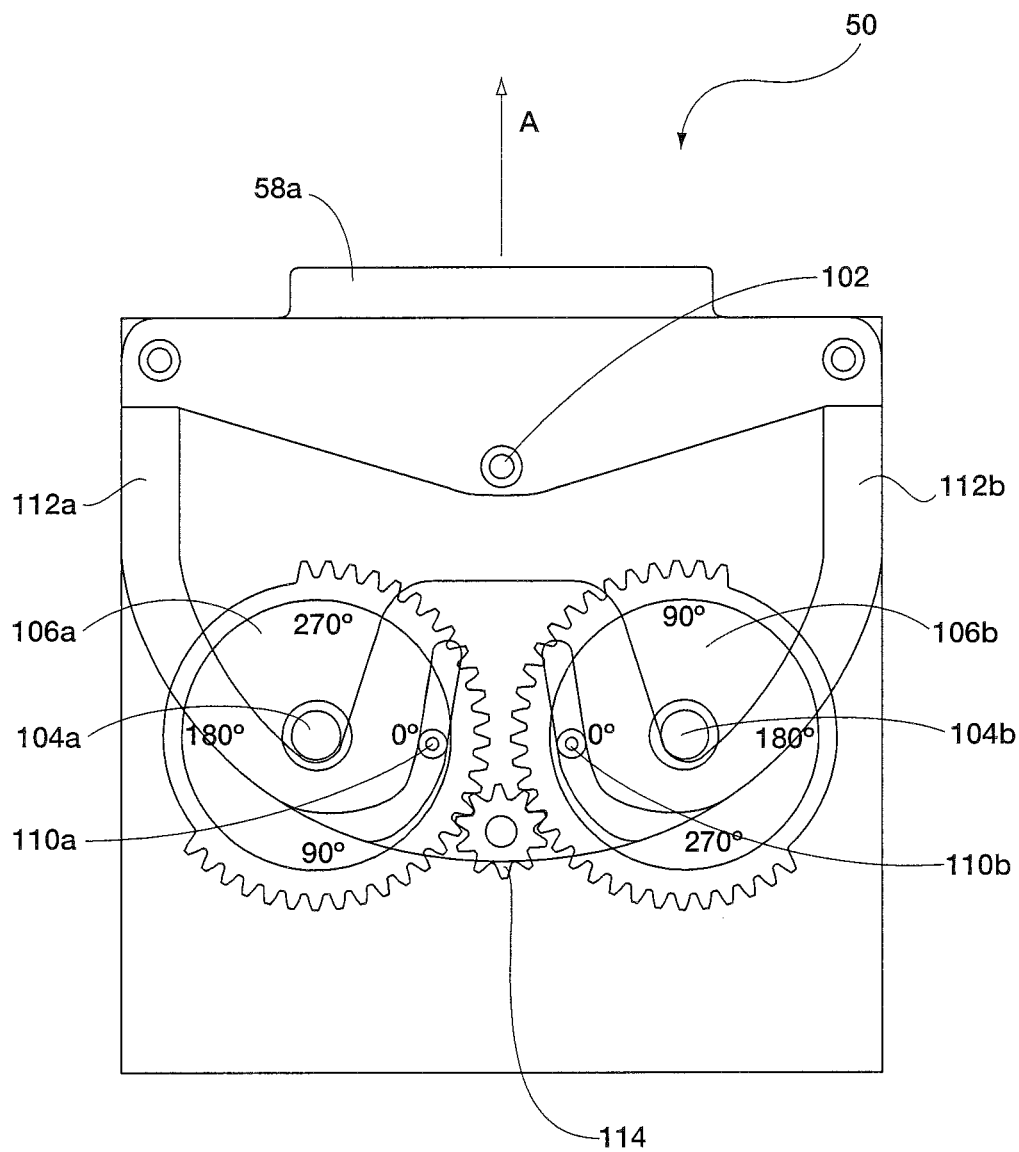


FIG. 5A

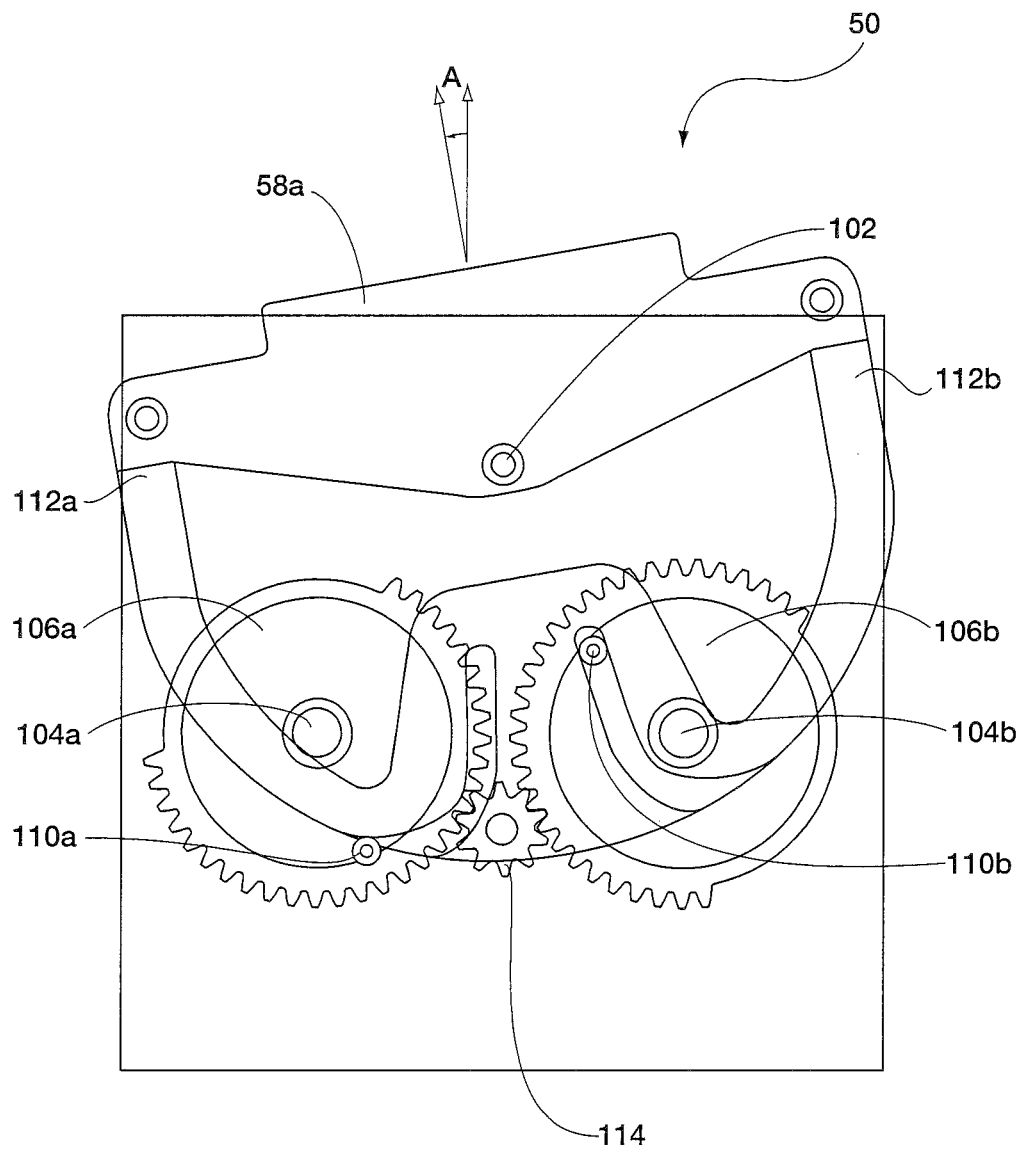


FIG. 5B



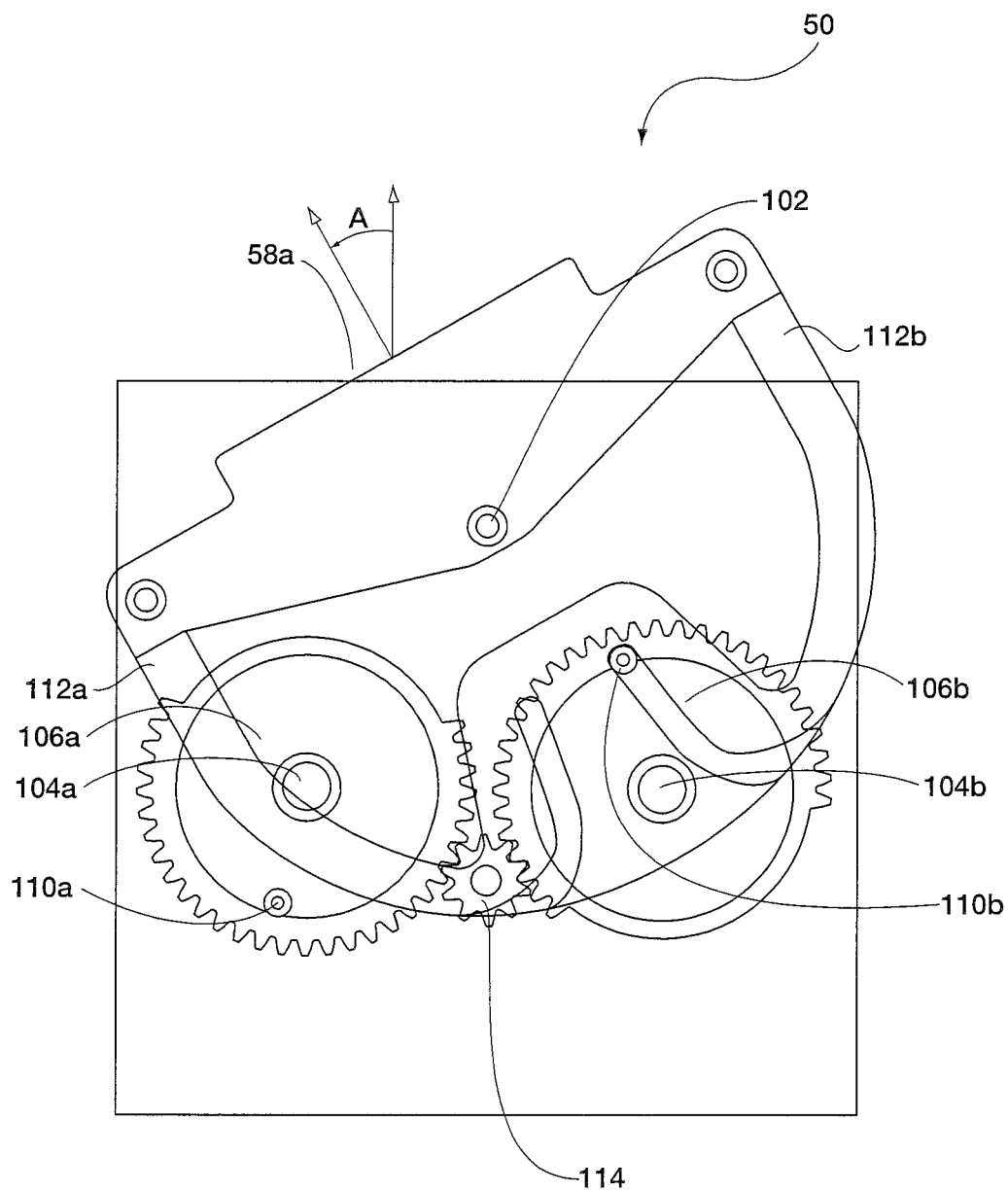


FIG. 5C

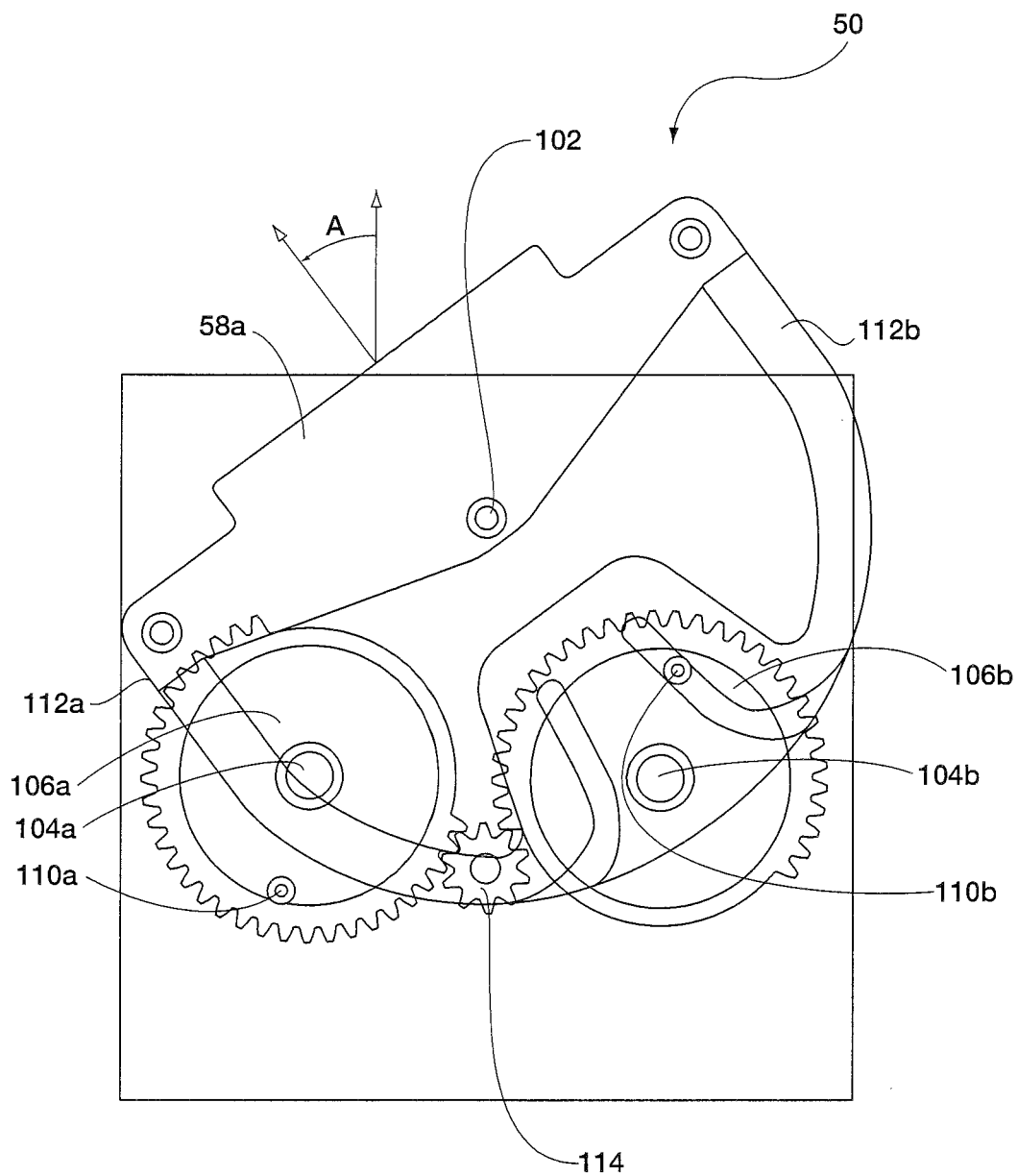


FIG. 5D

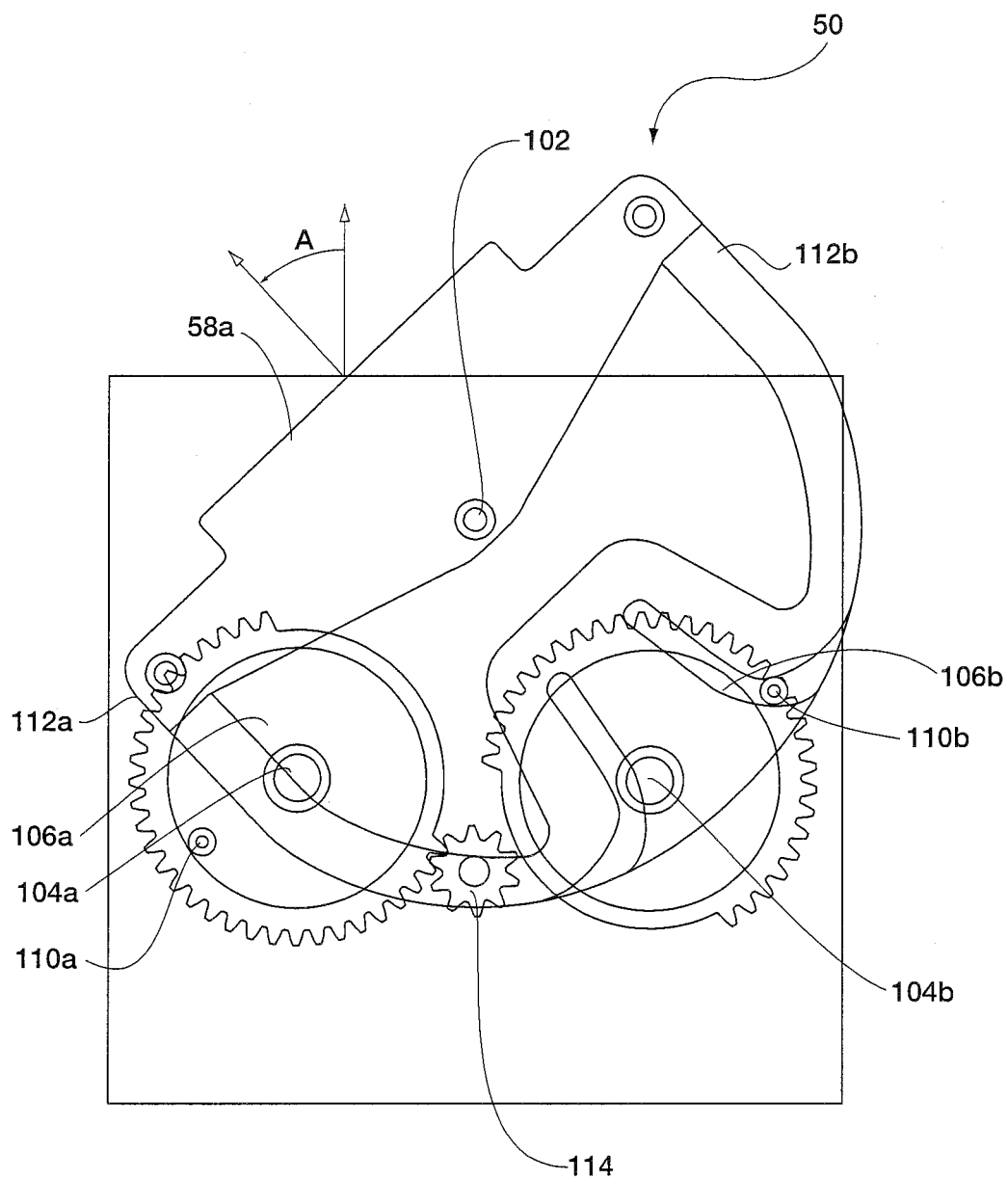


FIG. 5E

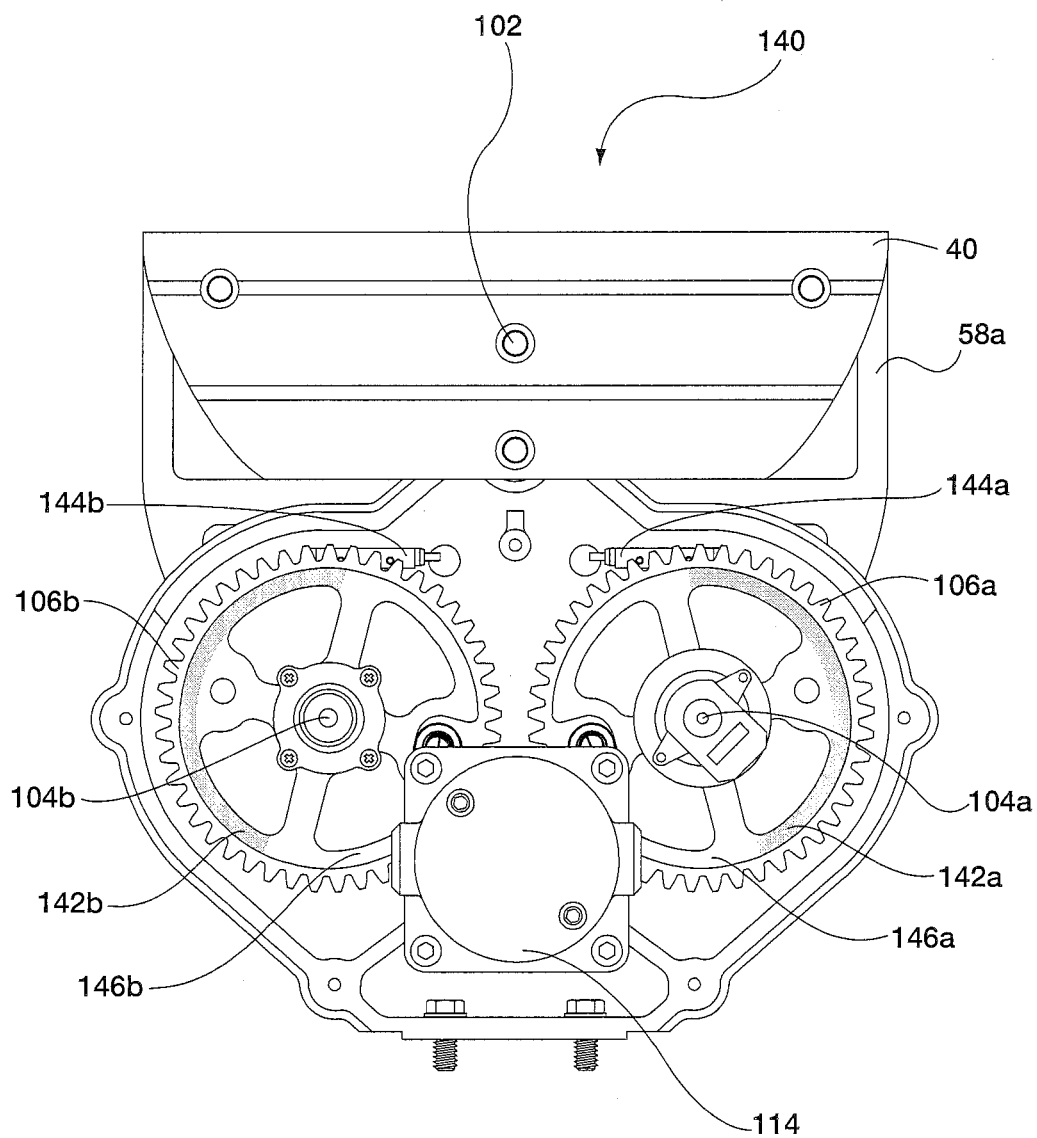


FIG. 6A

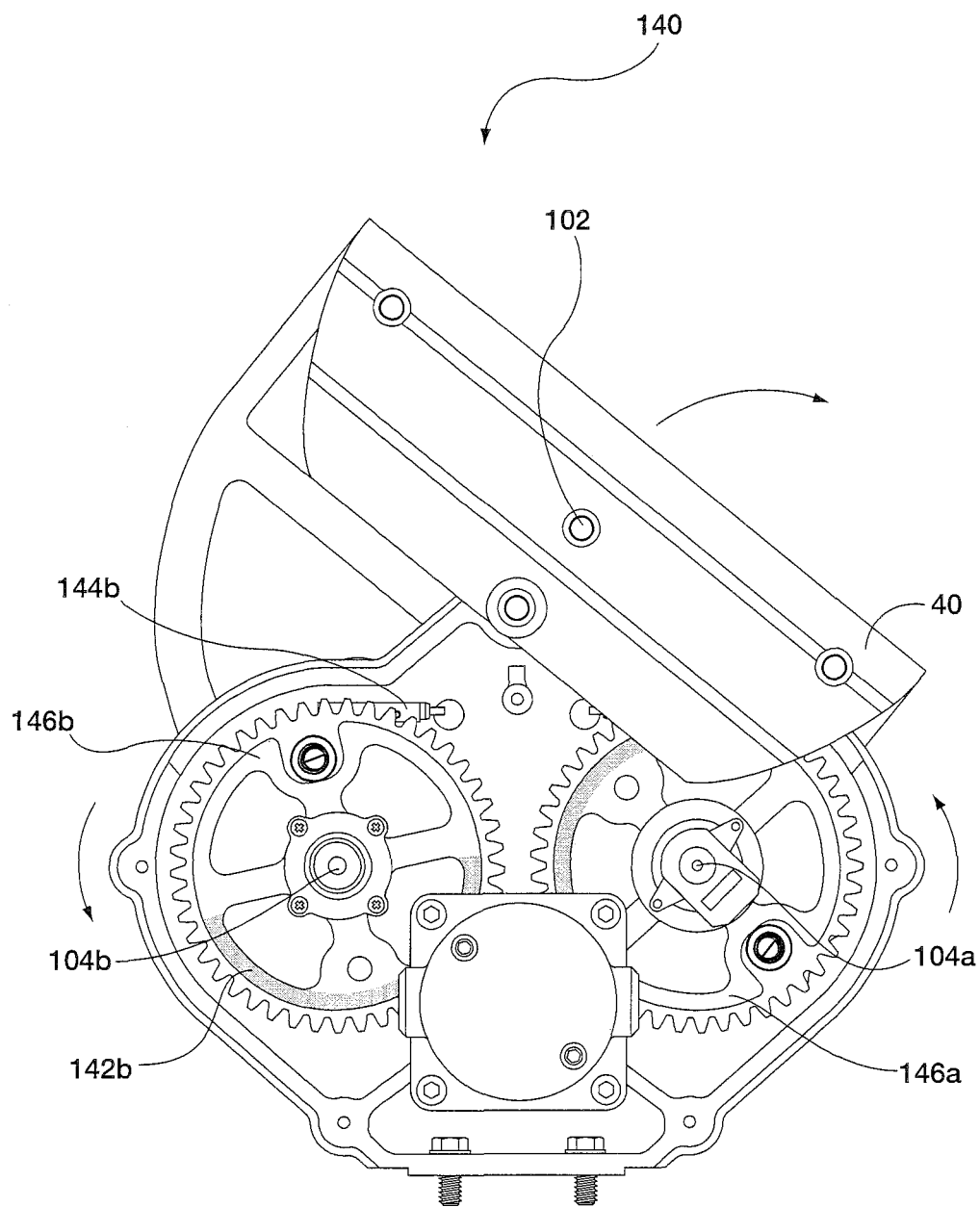


FIG. 6B

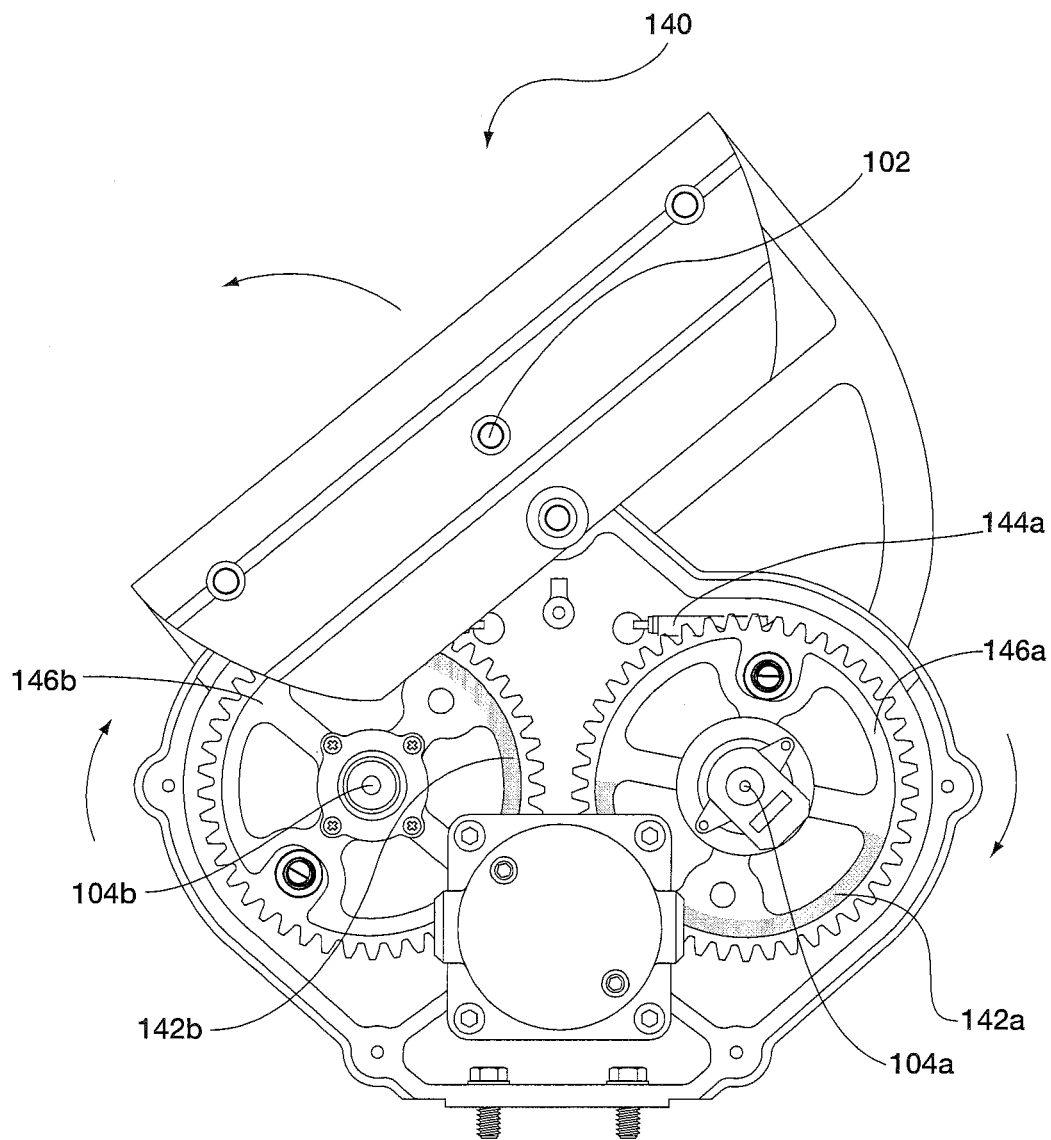


FIG. 6C

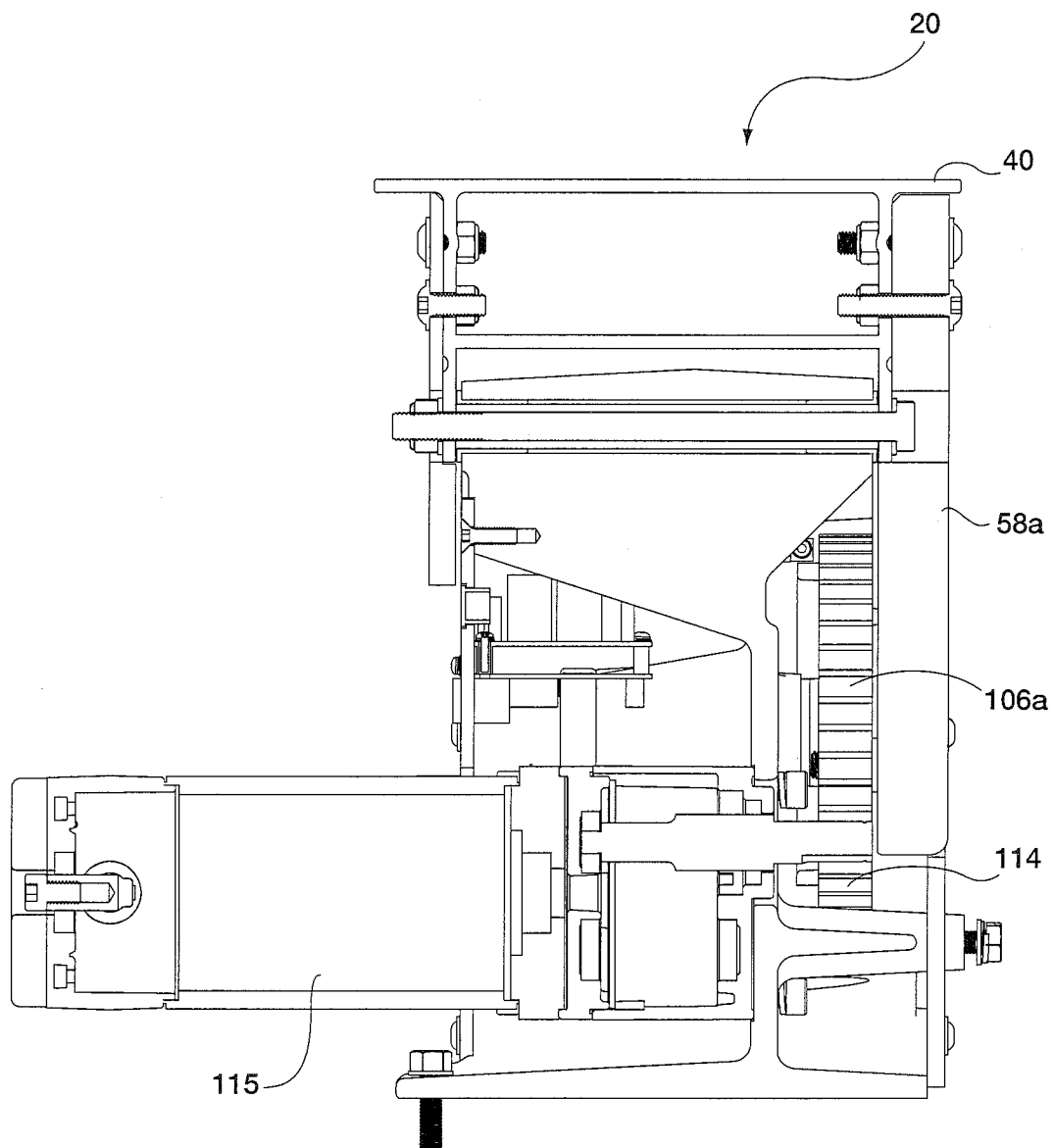
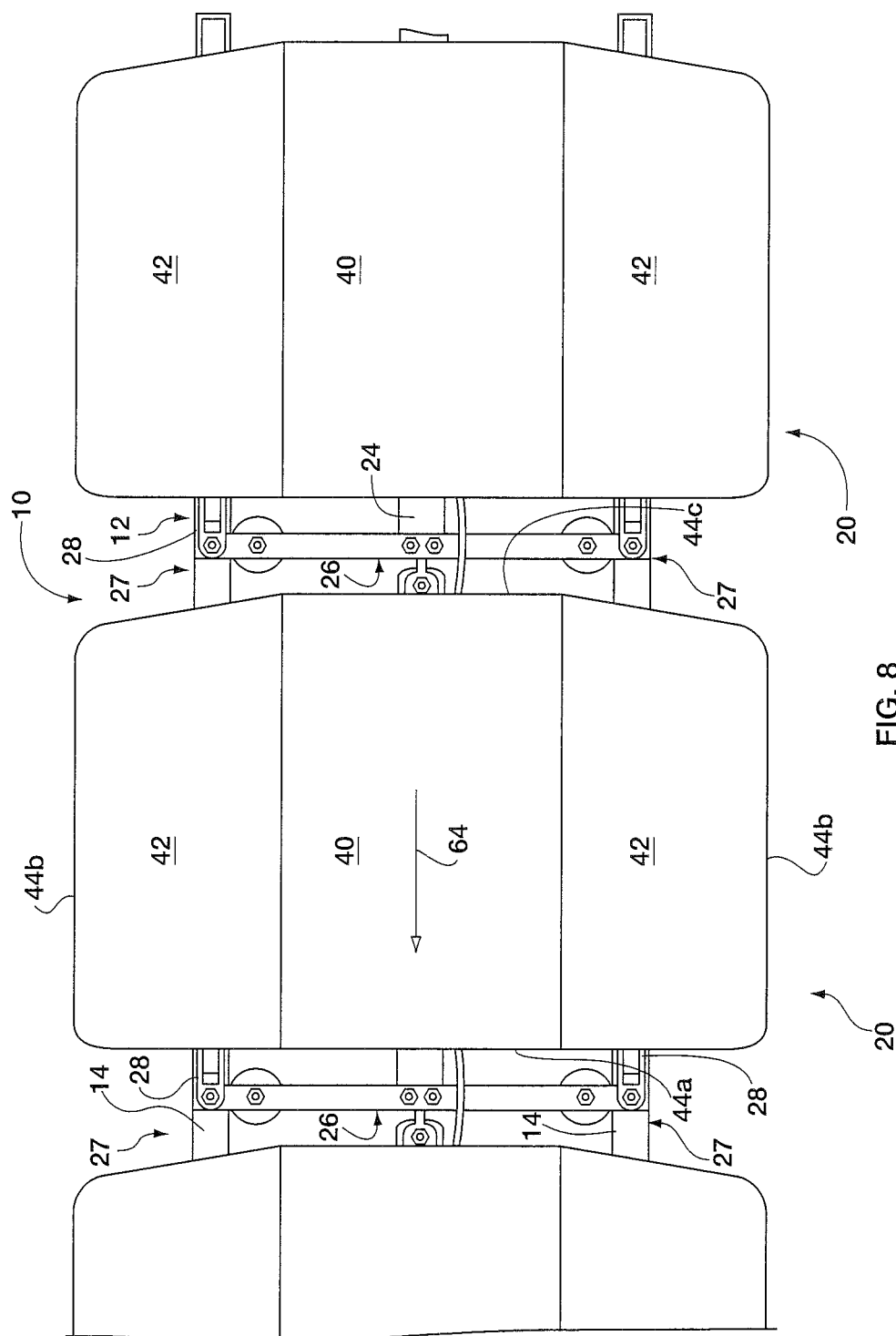


FIG. 7





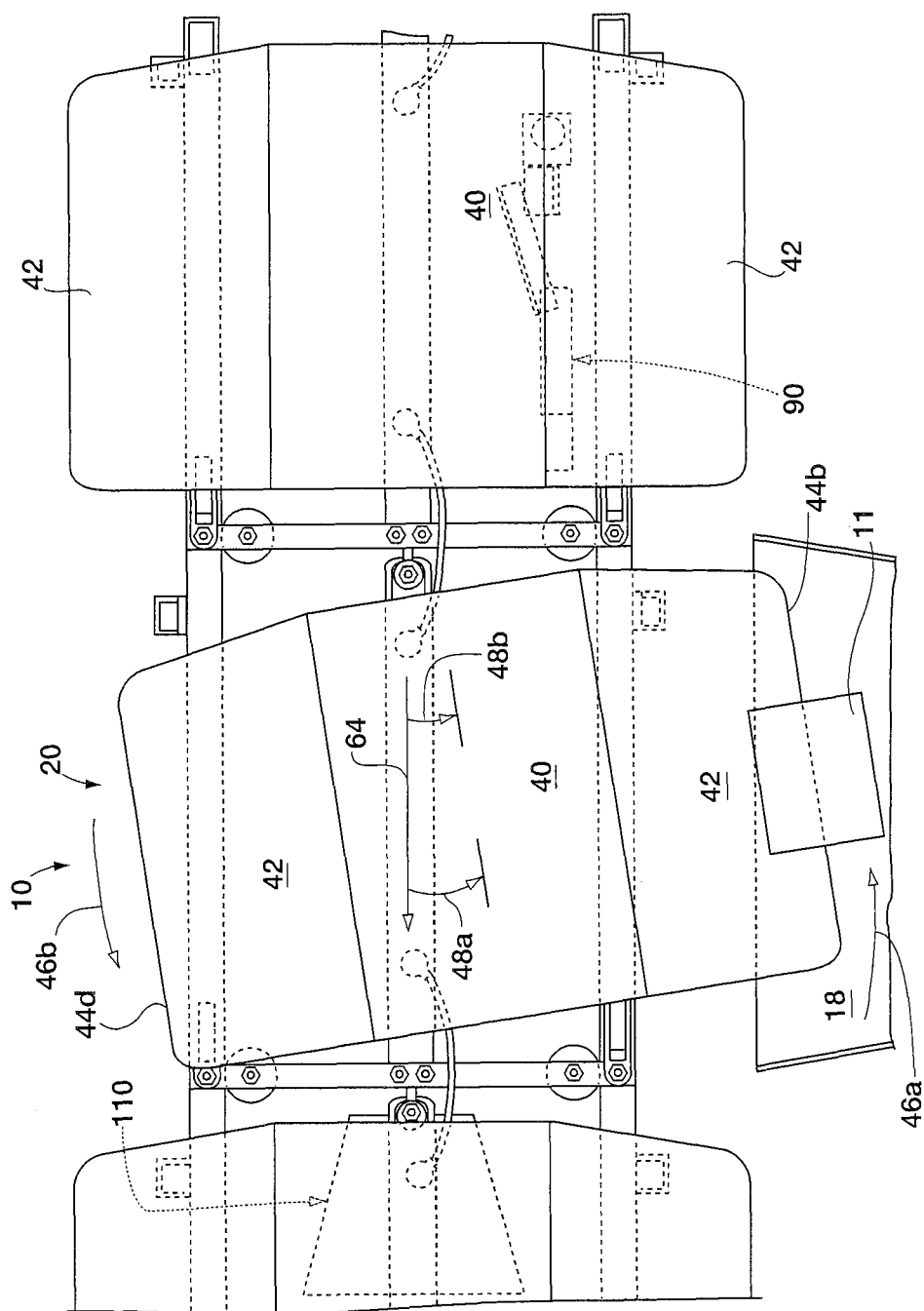


FIG. 8A

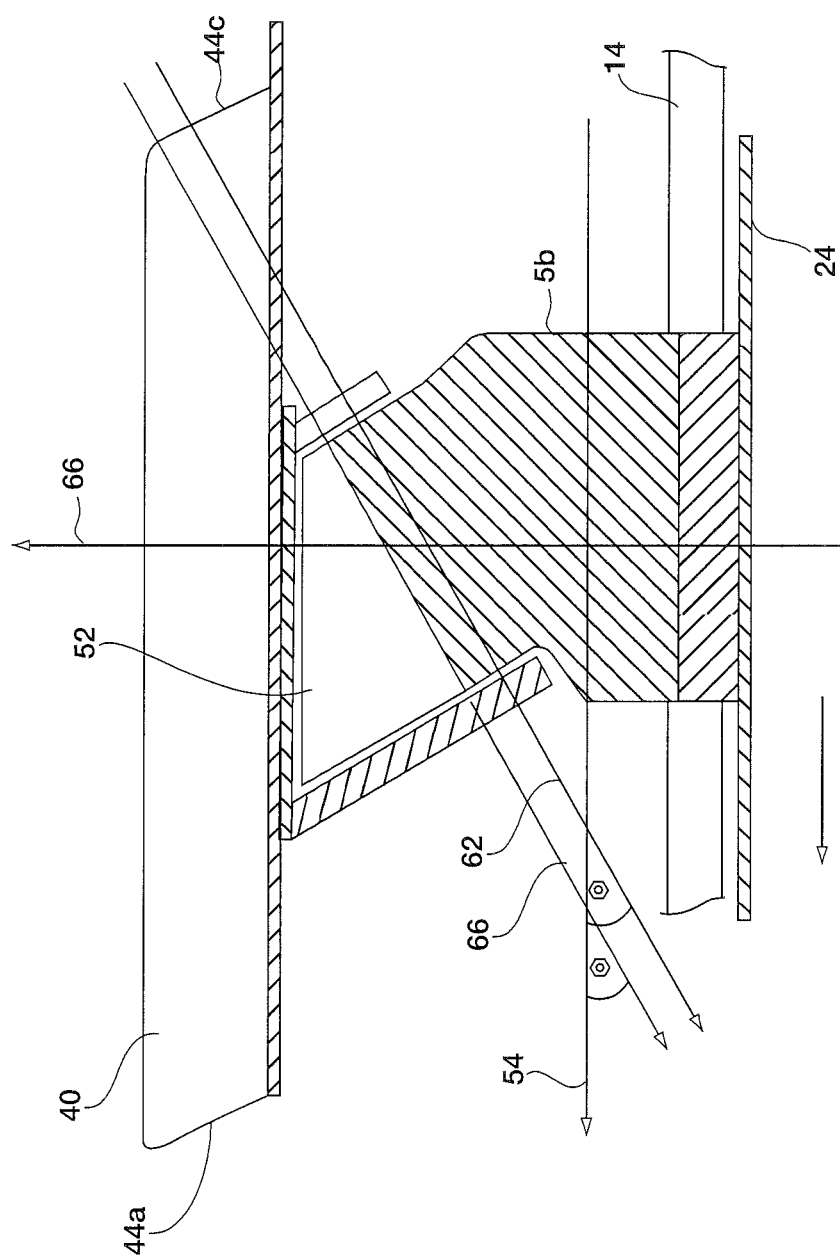
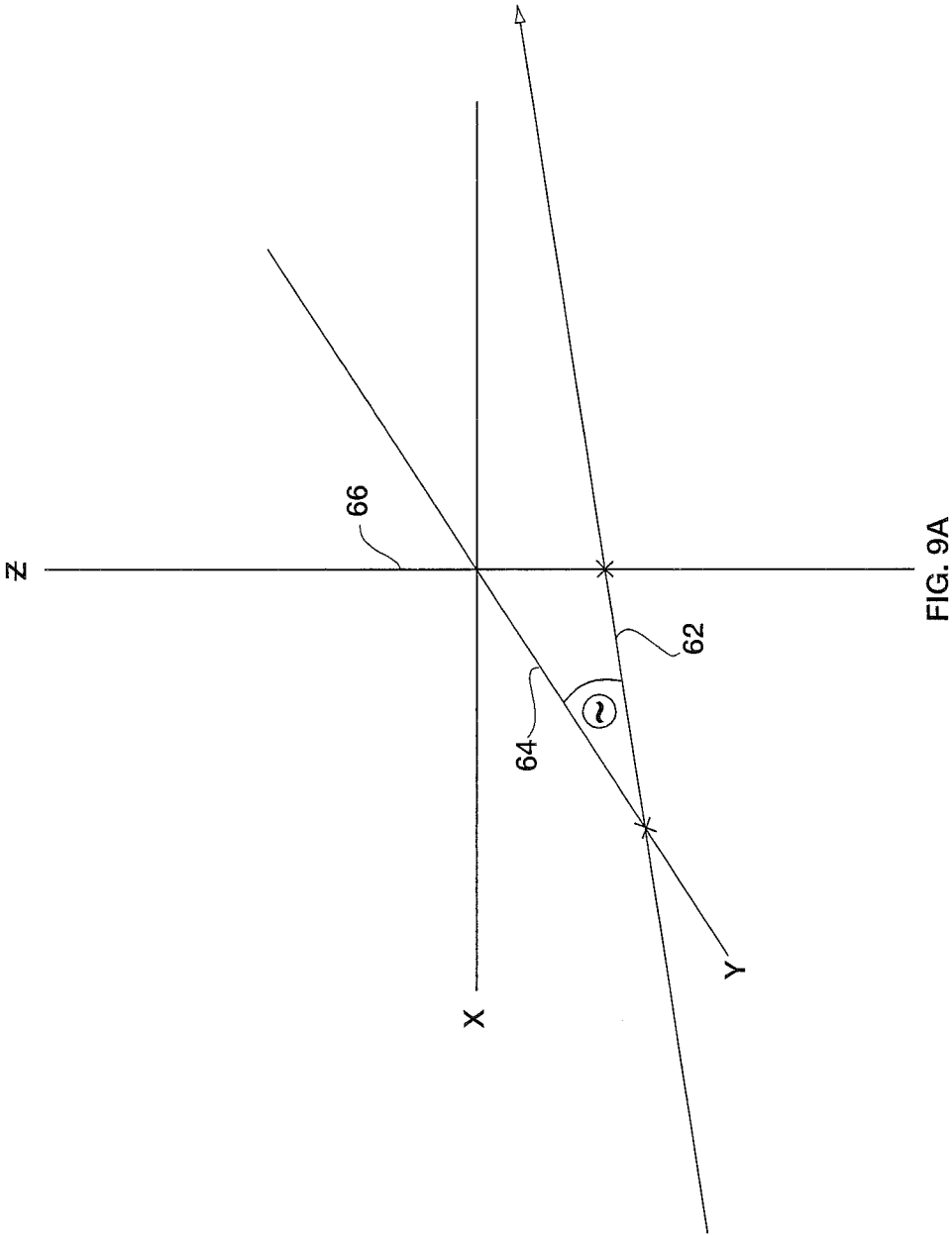


Fig. 9



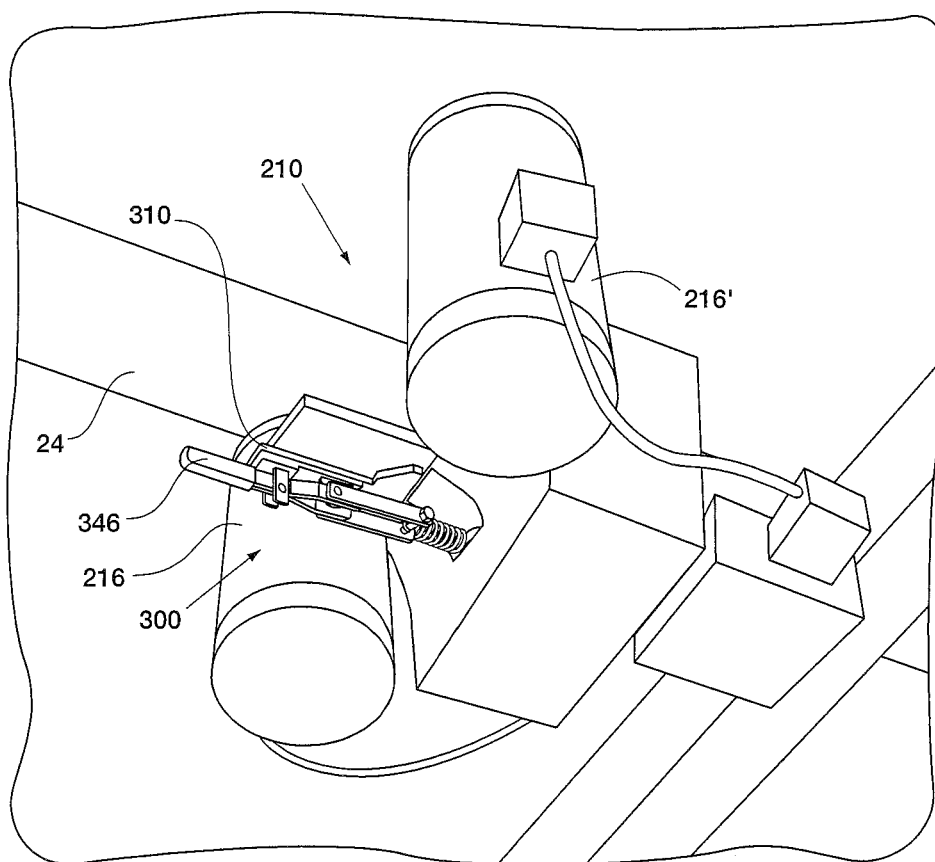


FIG. 10

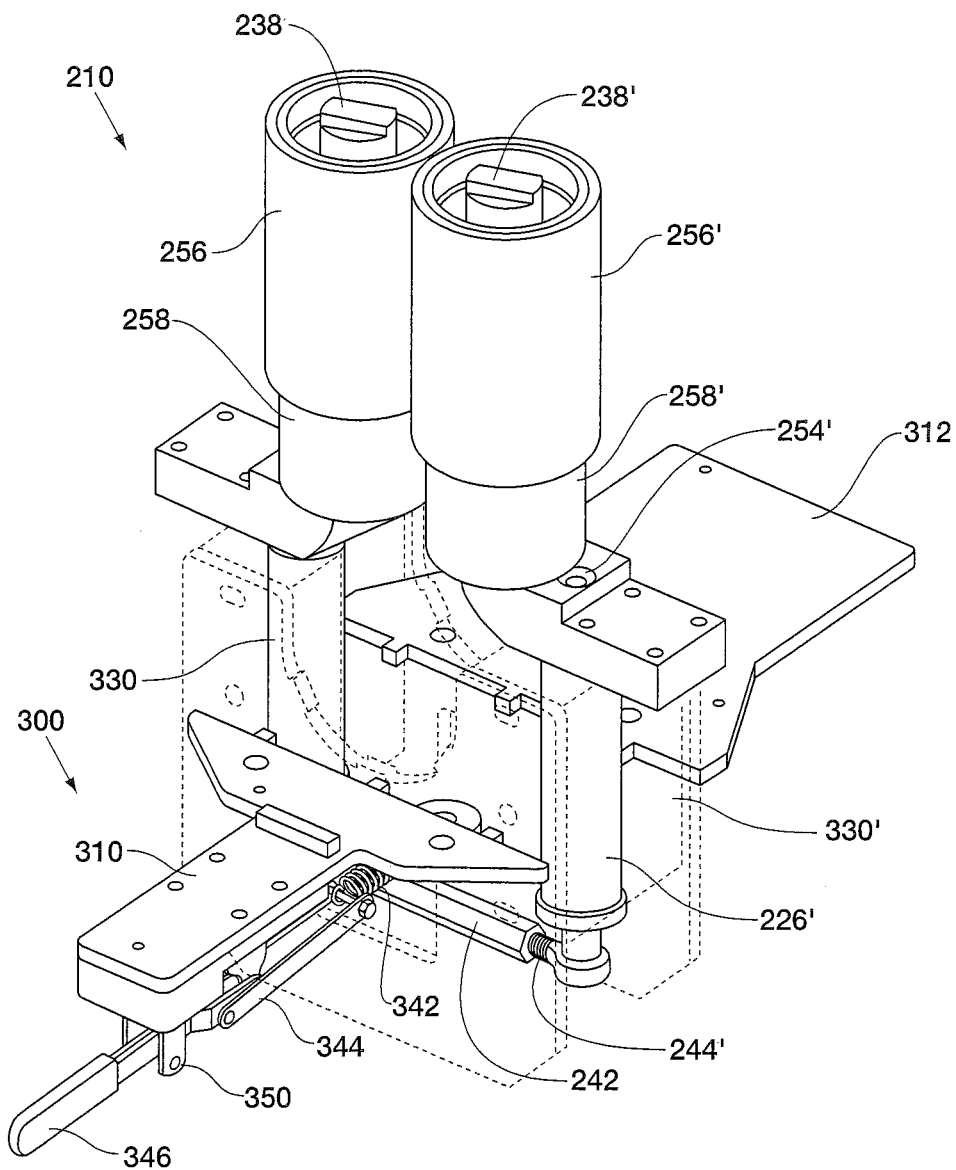


FIG. 11

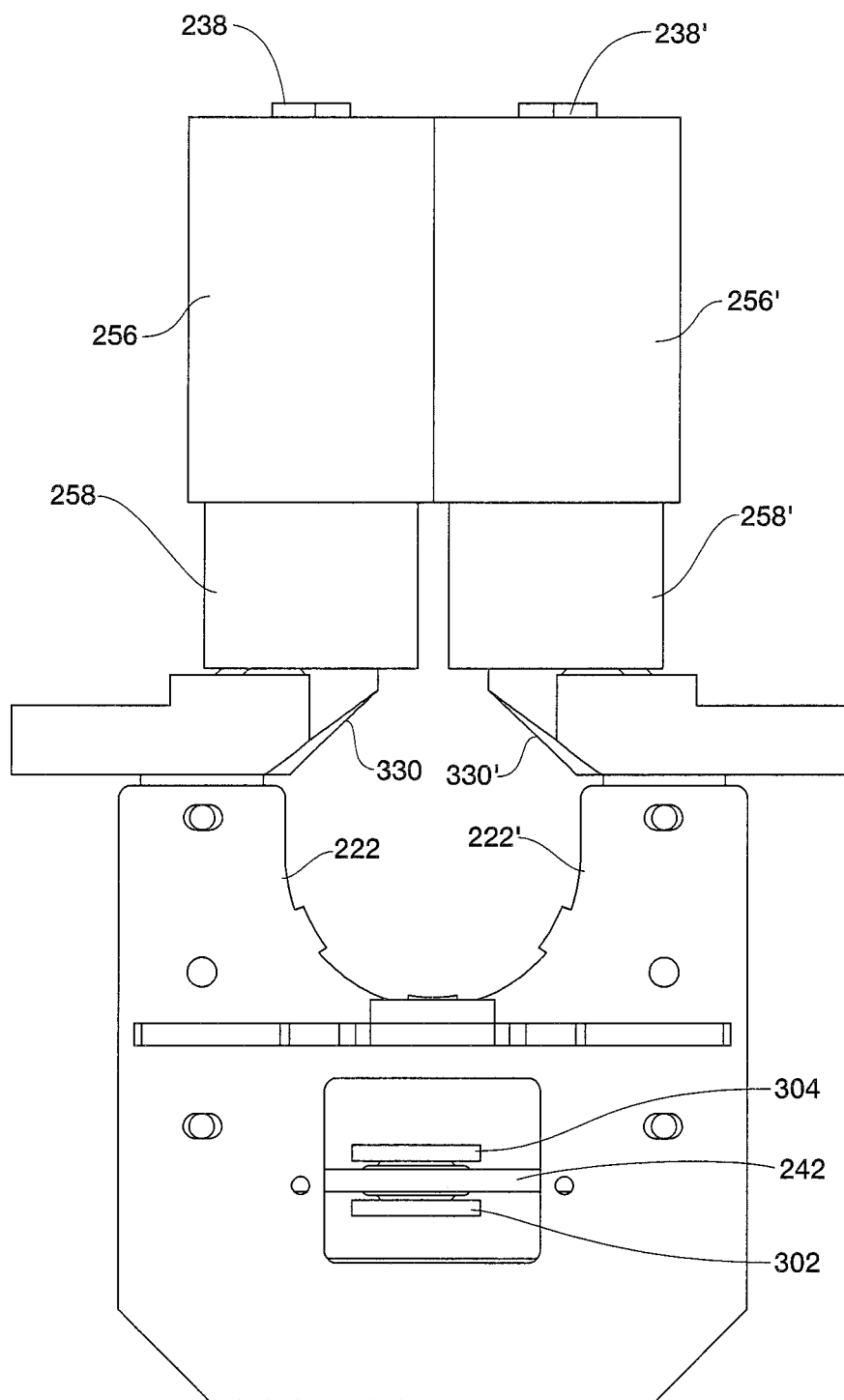


FIG. 12

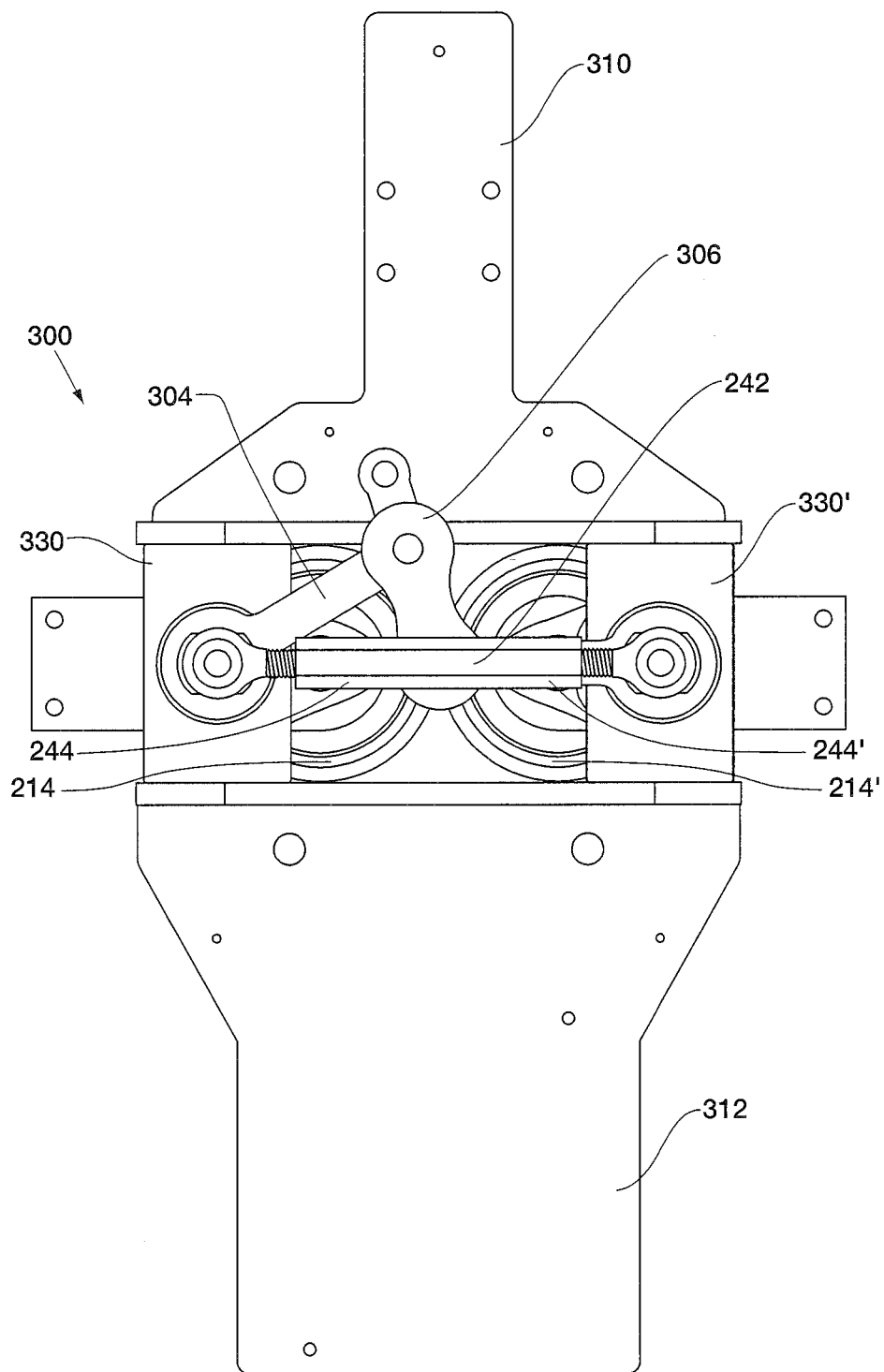


FIG. 13a

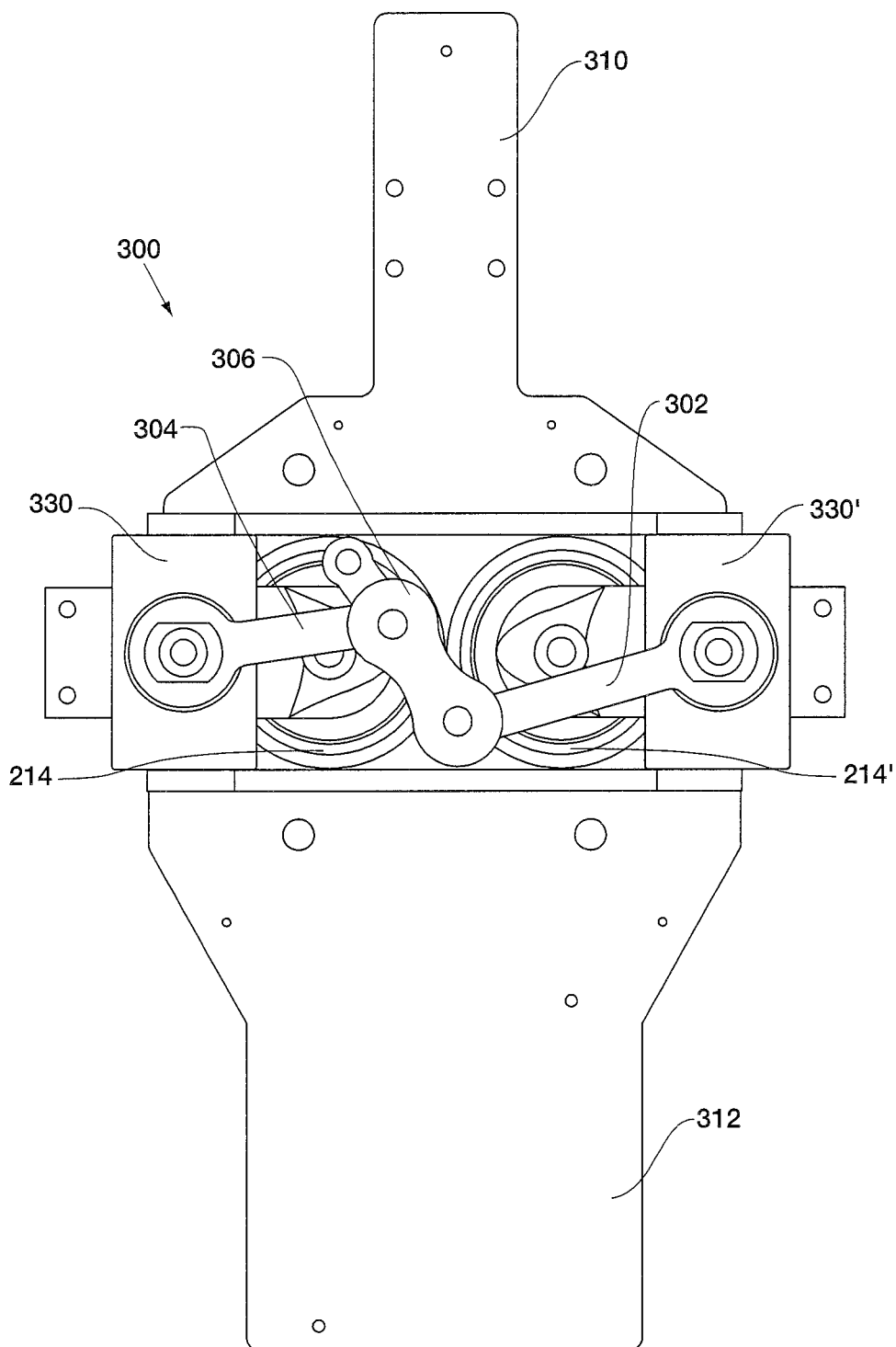


FIG. 13b



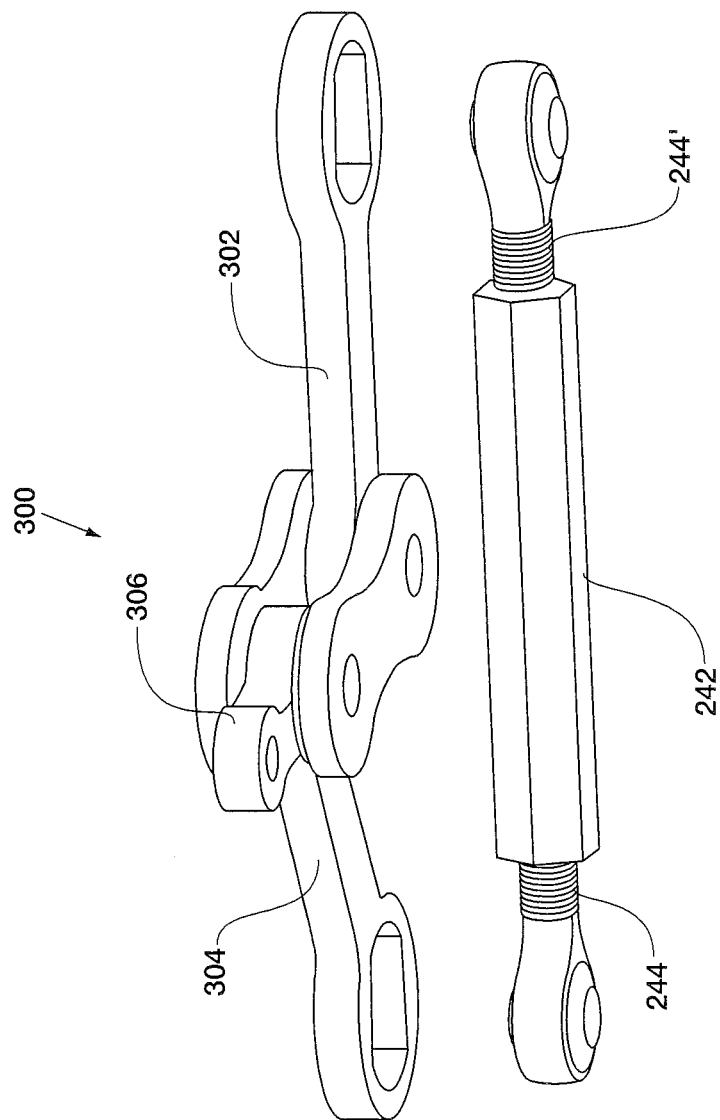


FIG. 14

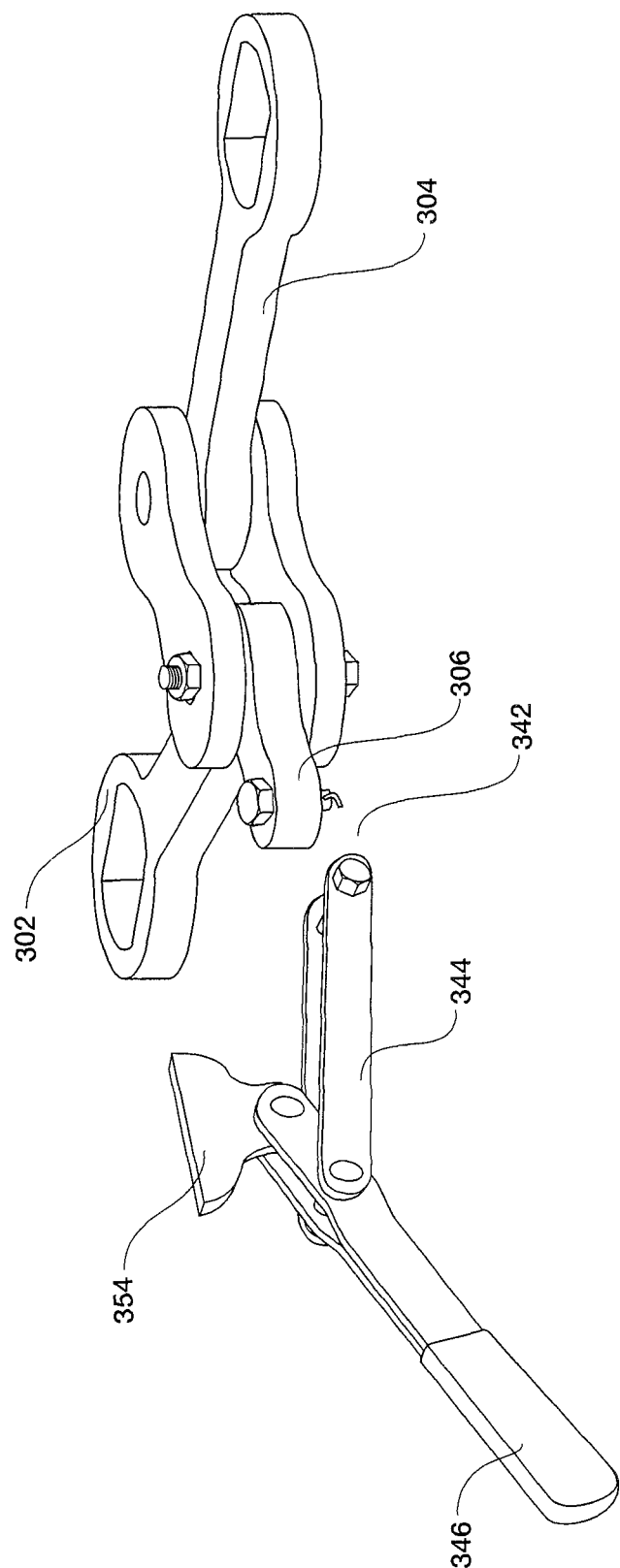


FIG. 15

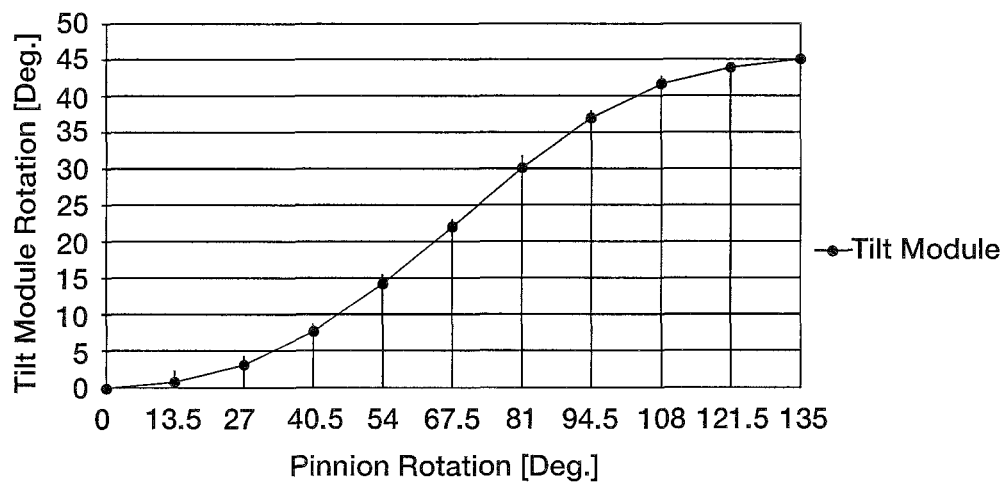


FIG. 16

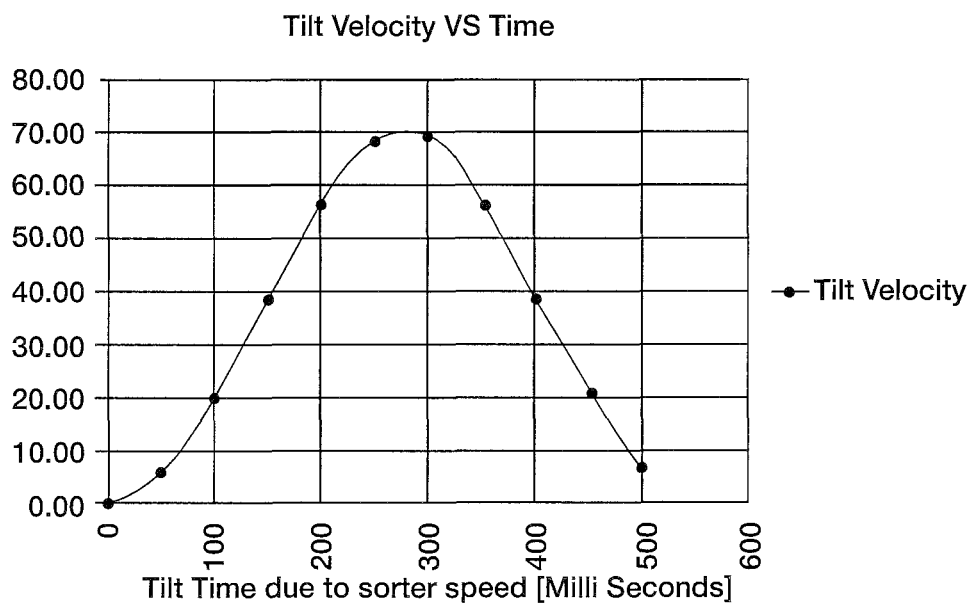


FIG. 17

1

## INDEPENDENT DISCHARGE SORTING CONVEYOR

### RELATED APPLICATIONS

This application is a continuation application of U.S. application Ser. No. 13/529,584 filed Jun. 21, 2012, which is incorporated herein by reference in its entirety.

### FIELD

The present inventions relate generally to package sorting conveyors and, more particularly, to a sorting conveyor having a tilting mechanism including at least one gear having at least one cam adapted for tilting the carrying tray toward at least one side of the conveyor.

### BACKGROUND

Conveyor systems having a number of individual carrying carts have been commonly used for many years to carry and sort packages or other items, such as mail. For example, U.S. Pat. No. 5,054,601 to Sjogren et al. discloses a package sorting conveyor comprised of a train of tilt tray carriers coupled in tandem to form a continuous loop. Each carrier includes a pivotally mounted tilt tray normally maintained in an upright position. The carriers are moved around the loop by a series of motors spaced around the loop. Branching out from the loop are outfeed chutes or the like for receiving packages from the carriers. When a particular carrier holding a particular package to be sorted reaches a selected outfeed chute, an actuator tilts the tray to dump the package into the outfeed chute. Another example of a typical package sorting conveyor is disclosed in International PCT Application Number PCT/DK90/00047 of Kosan Crisplant A/S, now U.S. Pat. No. 5,664,660.

It is also known in the art to use an electric motor for each supporting unit for causing the tilting movement of each load carrying platform. However, there are acceleration, deceleration and mechanical resistance challenges associated with electronically powering the tilt of each load carrying platform. Each tilt must occur precisely at the right moment; the electric motor must accommodate for a relatively heavy load during tilt; and the tray must be able to recover rapidly to a neutral position.

Additionally, it is difficult to track the tilt and position of each of the trays to ensure that each cart is properly functioning, positioned and prepared to repeatedly tilt, recover and deliver packages to the outfeed chutes without delay.

Thus, Applicant's a need for a sorting conveyor which includes individual conveyor carts having a new and improved tilting mechanism that is adapted for tilting the carrying tray while, at the same time, determining the direction of tilt of the tray.

### SUMMARY

The present inventions are directed to a sorting conveyor for transporting objects and unloading objects at one or more unloading stations adjacent the conveyor. The sorting conveyor includes a conveyor track and a train of conveyor carts connected end-to-end. At least one, including each, of the conveyor carts may include a frame base for engaging the conveyor track; a carrying tray for holding the objects; and a support for supporting the carrying tray above the frame base. A tilting mechanism including at least one gear having

2

at least one cam is adapted for tilting the carrying tray toward at least one side of the conveyor. The present inventions may further include a tilt sensor for determining the direction of tilt of the tray. In addition, a drive motor and a driven member attached to the frame base may be included for moving the conveyor carts around the track.

In one embodiment, the tilt sensor includes a direction indicator wherein the direction indicator is configured to sense a reference area on the gear. The tilt sensor may be a dual sensor for carts tipping to more than one side of the conveyor.

In one embodiment, the tilt sensor may include a positioning indicator wherein the positioning indicator is configured to sense a reference area on the at least one gear. The positioning indicator may be a dual sensor for carts tipping to more than one side of the conveyor.

In the tilting mechanism, the at least one cam is rotatable around an axis of rotation of the at least one gear between about 0 degrees and about 360 degrees. In one embodiment, the at least one cam travels between about 0 degrees and about 140 degrees around the axis of rotation. In one embodiment, the cam moves toward about 0 degrees in response to the tilt sensor. In operation, rotation of the at least one cam in a first direction around an axis of rotation of the at least one gear tilts the tray in a direction toward one side of the conveyor.

The tilting mechanism may also include a second gear having a second cam. Each cam movement may respond to the tilt sensor and whereby the tilt sensor may monitor a reference area on the gears. In operation, at least one cam actuates the tray toward a neutral position when the tilt sensor determines a not home signal on at least one the gear.

In one embodiment, the support is a tiltable support having an incremental tilting response to rotation of the first and second cams about an axis of rotation. The tiltable support may include at least one camway for housing the first cam and the second cam. In one embodiment, the cams are rotatable substantially between about 0 degrees and about 25 degrees about an axis of rotation of each gear respectively. Also, in one embodiment, one of the cams may be housed within a camway within the tiltable support and the other cam may be outside of the camway within the tiltable support when the cams are rotated substantially between about 25 degrees and about 135 degrees about an axis of rotation of each gear respectively. In operation, the tiltable support tilts between about 40 degrees and about 50 degrees around the axis of tilt when the first cam and the second cam are rotated between about 120 degrees and about 140 degrees around the axis of rotation of each gear respectively.

In one embodiment, the axis of rotation of the first gear and the second gear is between about 0 degrees and about 360 degrees. In one embodiment, the first cam and the second cam may travel between about 0 degrees and 140 degrees around the respective axis of rotation. In one embodiment, the first cam rotates about between 0 and 140 degrees around the axis of rotation of the first gear and the second cam rotates about between 0 and 140 degrees around the axis of rotation of the second gear. In operation, rotation of the first cam in a first direction around an axis of rotation tilts the tray in a direction toward one side of the conveyor and wherein rotation of the second cam in a second direction around an axis of rotation tilts the tray toward an opposite side of the conveyor than the one side.

In one embodiment, the first cam and the second cam each rotate about an independent axis of rotation. In operation,

3

rotation of the cams in a clockwise or counterclockwise direction is opposite the tilt of the tilt tray in a clockwise or counterclockwise direction.

The conveyor cart may further include at least one drive for actuating the tilting mechanism. In one embodiment, the drive is a gear drive for interacting with at least the first gear. Also, the tilting mechanism may be adapted so that each tray is independently dischargeable from the other trays in the conveyor train.

In one embodiment, the drive motor for moving the conveyor carts around the track may further include an opposed roller motor assembly for moving the conveyor carts on the conveyor track, the opposed roller motor assembly including a cantilevered, drive roller connected to one pivot block assembly and another pivot block assembly adapted for positioning the drive roller, wherein the pivot block assemblies are coupled together and adapted so that movement of each pivot block assembly mirrors movement of the other pivot block assembly. Also, the pivot block assemblies may be coupled together with a self-tensioning adjustment assembly including (i) at least one motor adjustment link affixed to one of the pivot block assemblies, (ii) a second link affixed to the other pivot block assembly, and (iii) a connecting roller link coupling the at least one motor adjustment link and the second link.

In one embodiment, the frame base may include a lower base portion attached to the conveyor track and the self-tensioning adjustment assembly. Also, the self-tensioning adjustment assembly may include a drive clamp plate connected to the lower base portion. In one embodiment, a lever may be connected to the self-tensioning adjustment assembly and adapted to adjust the pivot block assemblies. In one embodiment, the lever is adapted so that movement of each pivot block assembly mirrors movement of the other pivot block assembly.

Also, in one embodiment, the self-tensioning adjustment assembly includes a self-tensioning clamp plate for supporting the lever. The self-tensioning clamp plate may include a mounting bracket connecting a proximate end of the lever to the self-tensioning clamp plate. Also, the self-tensioning assembly may include a lever retainer affixed to the self-tensioning clamp plate to retain a distal handling end of the lever in an operating position. The self-tensioning assembly also may include a coupling arm connecting the lever and the connecting roller link. The self-tensioning assembly may further include a spring assembly between the coupling arm and the connecting roller link.

In one embodiment, the second link is a motor adjustment link.

In one embodiment, the drive roller assembly includes a generally cylindrical roller having an outer elastomeric surface for frictionally engaging the driven member extended fin. The elastomeric surface may be a polyurethane. In one embodiment, the polyurethane has a Shore A hardness between about 70 and about 80.

In one embodiment, the motor assembly includes a rotary motor and a drive belt connecting the motor and the drive roller, wherein the drive roller includes a frictional surface for receiving the drive belt. Also, in one embodiment, an opposing surface is adjacent to another surface of the driven member for off-setting the mechanical load of the drive roller in a second drive roller assembly. The second drive roller assembly may further include a second motor assembly.

In one embodiment, the driven member of the frame base comprises a fin moved in the conveyor line of travel by the opposed roller motor assembly. The opposed roller motor

4

assembly and the fin may both be vertically oriented beneath the trailer frame base. In one embodiment, the fin is generally parallelogram-shaped with rearwardly angled front and rear edges.

Accordingly, one aspect of the present inventions is to provide a sorting conveyor for transporting objects and unloading objects at one or more unloading stations adjacent the conveyor, the sorting conveyor comprising: (a) a conveyor track; (b) a train of conveyor carts connected end-to-end; and (c) at least one of the conveyor carts including (i) a frame base for engaging the conveyor track; (ii) a carrying tray for holding the objects; (iii) a support for supporting the carrying tray above the frame base; and (iv) a tilting mechanism including at least one gear having at least one cam for tilting the carrying tray toward at least one side of the conveyor.

Another aspect of the present inventions is to provide in a sorting conveyor for transporting objects and unloading objects at one or more unloading stations adjacent the conveyor, the sorting conveyor having a conveyor track and a train of conveyor carts connected end-to-end, at least one of the conveyor carts comprising: (a) a frame base for engaging the conveyor track; (b) a carrying tray for holding the objects; (c) a support for supporting the carrying tray above the frame base; (d) a tilting mechanism including at least one gear having at least one cam for tilting the carrying tray toward at least one side of the conveyor; and (e) a tilt sensor for determining the direction of tilt of the tray.

Still another aspect of the present inventions is to provide a sorting conveyor for transporting objects and unloading objects at one or more unloading stations adjacent the conveyor, the sorting conveyor comprising: (a) a conveyor track; (b) a train of conveyor carts connected end-to-end; (c) at least one of the conveyor carts including (i) a frame base for engaging the conveyor track; (ii) a carrying tray for holding the objects; (iii) a support for supporting the carrying tray above the frame base; (iv) a tilting mechanism including at least one gear having at least one cam for tilting the carrying tray toward at least one side of the conveyor; and (vi) a tilt sensor for determining the direction of tilt of the tray; and (d) a drive motor and a driven member attached to the frame base for moving the conveyor carts around the track.

These and other aspects of the present invention will become apparent to those skilled in the art after a reading of the following description of the preferred embodiment when considered with the drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic depiction of one embodiment of a package sorting conveyor constructed according to the present inventions;

FIG. 2 is front elevational view of a single tilting conveyor cart of a package sorting conveyor and an opposed roller motor assembly of the conveyor;

FIG. 3 is a side view of one embodiment of the tilting conveyor cart shown in FIG. 2, which also shows the tiltable support apparatus of the tilting conveyor cart of the inventions;

FIG. 4 is a side view of one embodiment of the tilting conveyor cart shown in FIG. 2;

FIGS. 5A-5E show a tilting mechanism in different positions as the carrying tray tilts toward at least one side of the conveyor;

FIG. 6A shows one embodiment of a tilt sensor when the tray is in a neutral position;

5

FIG. 6B shows one embodiment of a tilt sensor when the tray is in a tilted position;

FIG. 6C shows one embodiment of a tilt sensor when the tray is in a tilted position opposite that seen in FIG. 6B;

FIG. 7 is a cross-sectional side view of one embodiment of the tilting mechanism of the present inventions;

FIG. 8 is a top view of the train of carts of one embodiment of the sorting conveyor of the present inventions;

FIG. 8A shows the train of carts of FIG. 8, but with one of the carts in its tilted position and unloading a package onto an unloading station beside the sorting conveyor track;

FIG. 9 is a side view of one embodiment of a tilting conveyor cart;

FIG. 9A is a geometric depiction of one embodiment of the conveyor cart pivot axis and conveyor line of travel as they relate to three-dimensional X,Y,Z spatial coordinates;

FIG. 10 is a bottom perspective view of the opposed motor roller assembly, with the track elements omitted for clarity;

FIG. 11 is a perspective view of an isolated opposed motor roller assembly, with the elements shown in phantom and omitted for clarity;

FIG. 12 is an enlarged side perspective view of an isolated opposed motor roller assembly, with elements omitted for clarity;

FIG. 13a is an enlarged bottom view of a self-tensioning adjustment assembly and opposed motor roller assembly, with elements omitted for clarity;

FIG. 13b is an enlarged bottom view of a self-tensioning adjustment assembly and opposed motor roller assembly, with elements omitted for clarity, in a second maintenance position;

FIG. 14 is an enlarged side perspective view of isolated elements in the self-tensioning adjustment assembly, with elements omitted for clarity;

FIG. 15 is another enlarged side perspective view of isolated elements in the self-tensioning adjustment assembly, with elements omitted for clarity;

FIG. 16 is a graph illustrating gear rotation as compared to tray tilt rotation in degrees; and

FIG. 17 is a graph illustrating tray tilt time versus tilt velocity.

#### DETAILED DESCRIPTION OF EMBODIMENTS

In the following description, like reference characters designate like or corresponding parts throughout the several views. Also in the following description, it is to be understood that such terms as “forward”, “rearward”, “left”, “right”, “upwardly”, “downwardly”, and the like are words of convenience and are not to be construed as limiting terms.

Referring now to the drawings in general and FIGS. 1, 2 and 3 in particular, it will be understood that the illustrations are for the purpose of describing embodiments of the inventions and are not intended to limit the inventions thereto. As best seen in FIG. 1, a sorting conveyor, generally designated 10, is shown constructed according to the present inventions for transporting and sorting packages 11 or other objects. The sorting conveyor 10 comprises a train of individual carts 20, connected end to end, which may form an endless loop around a closed-circuit conveyor track 12. Alternately, the conveyor carts 20 of the inventions could be used singly or as part of a finite train.

The sorting conveyor 10 generally includes a conveyor track 12 and the train of conveyor carts 20 that are generally moved around the track by one or more drive motors (not shown in FIG. 1). Each of the conveyor carts typically

6

includes a frame base 22 for engaging the conveyer track; a carrying tray 40 for holding the objects; a support 58a for supporting the carrying tray above the frame base; and a tilting mechanism 50 for tilting conveyor carts 20 to discharge packages 11 therefrom. Typically, any number of unloading stations or outfeed chutes 18, which are adjacent the package sorting conveyor 10 on one or both sides thereof, receive the packages 11 discharged from the sorting conveyor 10 and carry the packages to waiting storage bins, trucks, etc. Packages may be manually placed on the conveyor carts 20 or may be delivered to the sorting conveyor 10 via infeed chutes 17 or the like.

The conveyor track 12 includes two parallel rails 14 and may be built to conform to the layout of any warehouse, shipping center, distribution center or the like. Best seen as resembling the track of a roller coaster, the conveyor track 12 may be substantially horizontal or may ascend and descend. The conveyor track rails 14 may lie in the same horizontal plane, or one may be higher than the other, such as would be the case in a banked curve in the track 12. Banked curves are greatly advantageous because they allow the conveyor carts 20 to move around a curved conveyor track 12 at a much greater speed without spilling packages 11 than on a flat track. Typically, the rails 14 are generally tubular, again similar to a roller coaster, and are supported by rail support members 16 only on the outwardly facing edges of the rails. The rails 14 may typically be round, however, may also be rectangular or take on other shapes in cross-section.

Now turning to the train of conveyor carts 20, each cart 20 generally may include: a trailer frame base 22, a generally horizontally disposed carrying tray 40 for holding the packages 11, and a support 58a for supporting the carrying tray 40 above the trailer frame structure 22 and for allowing tilting of the carrying tray 40 towards either side of the sorting conveyor 10 to unload a package into one of the unloading stations. Each cart 20 is built around the trailer frame base 22 to which other components of each cart 20 are mounted. As shown in FIGS. 2 and 4, the trailer frame structure 22 includes a longitudinal base member 24 that extends in the rearward direction of conveyor travel 64 between the two parallel rails 14. Preferably, the base member 24 is substantially equidistant from each rail 14.

A roller structure 26 for riding on the conveyor track 12 is mounted on a front end of the base member 24 and includes two laterally extending cam follower mechanisms 27, one for each rail 14. The reason for the outboard placement of the rail supports 16 and the tubular shape of the rails 14 becomes apparent upon examining the cam follower mechanisms 27. Each cam follower mechanism 27 may include three cam followers: an upper cam follower 30a for riding on the top edge of the rail 14, a middle cam follower 30b for riding on an inside edge of the rail 14, and a lower cam follower 30c for riding on the bottom edge of the rail 14. With this configuration, it is almost impossible for a cart 20 to jump the track 12, because a wheel is provided for each directional force (sideways, upward and downward) that a cart 20 may encounter when traveling along the track 12. Preferably, each cam follower 30a, 30b and 30c is constructed of a somewhat resilient material such as polyurethane to provide for smooth, quiet, relatively vibration-free operation of the sorter conveyor 10.

The structure of one embodiment of each cam follower mechanism 27 that holds the top wheel 30a is shown in greater detail in U.S. Pat. No. 5,836,436, which is herein incorporated by reference in its entirety. Each top cam follower 30a is retained by an axle caster 28 that is prefer-

ably formed from extruded aluminum or the like. The axle caster **28** includes two forks, one on each side of the wheel **30a**, and a bearing bore disposed at the juncture of the two forks which has an opening on one side so that the bearing bore communicates with the space between the forks. A pair of flange bearings seated in the bearing bore are disposed around an axle shaft extending from the roller structure **26**. Preferably formed of an Oilite® metal alloy or other friction-reducing material, each flange bearing has the form of a top-hat bushing and includes a center hole through which passes the axle shaft. The cam follower **30a** is held in place between the two forks by a bolt and nut. Preferably, the cam follower **30a** includes a bearing structure disposed around the bolt, which serves as an axle running through the center of the wheel **30a**.

The axle caster **28** of the present inventions provides that the flange bearings can easily be slid into place by hand into the bearing bore **28** without using a press. Then, to immovably secure the flange bearings inside the bearing bore, the forks are slightly flexed inwardly towards each other as the nut is tightened onto the bolt to hold the wheel **30a** in place. The forks of the axle caster are therefore formed minutely wider apart than would be necessary to merely hold the wheel **30a**. When the forks are flexed inwardly towards each other by tightening the nut on the bolt, the opening of the bearing bore is closed somewhat and the bearing bore is itself slightly distorted, securely retaining the flange bearings therein. The flange bearings themselves are, however, not significantly distorted and are free to swivel back and forth on the axle shaft. Therefore, the flange bearings can easily and immediately be replaced on-site when worn, eliminating much down-time that would be required if conventionally designed axle casters were used in the conveyor cart **20** of the present invention.

Adjacent carts **20** in the train are connected together using hitch mechanisms **32**. Each hitch mechanism **32** as including a front hitch mounted on the front end of the base member **24** in front of the roller structure **26** and a rear hitch mounted on the rear end of the base member. In one embodiment, each hitch **32** has a vertical throughbore, through which a hitch pin connector is inserted. The hitch mechanisms **32** may be configured so that the front hitch on a rearward cart is disposed overtop of the rear hitch on a forward cart. In the alternative, the hitch mechanisms **32** may comprise a polydirectional spherical ball joint mechanism similar in structure to an automotive trailer hitch. In either case, friction between hitch mechanism components is preferably reduced by, for example, lining the hitch components with TEFLON® polymer or other relatively low-friction material.

To prevent adjacent conveyor carts **20** from separating should the hitch mechanism **32** accidentally break or become uncoupled, an auxiliary cart connector **34** is preferably connected between the trailer frame structures **22** of adjacent carts **20**. The auxiliary cart connector **34** may be a metal cable or lanyard, although other high-tensile strength materials could be used. In the embodiment depicted, the auxiliary cart connector **34** is an approximately 3/16th inch thick metal cable connected to adjacent trailer frame structures **22** with metal mounting connectors **34a**.

The primary reason that metal is the preferred material for the auxiliary cart connector **34**, besides its strength, is so that the auxiliary cart connector **34** will also serve as a continuous electrical connector between adjacent carts **20**. Electrical continuity between carts **20** is important because of static electricity build-up while the carts **20** are traveling around the conveyor track **12**. However, because the cam followers **30a**, **30b** and **30c** are preferably formed of polyurethane (an

electrical insulator) and because the components of the hitch mechanism **32** are preferably coated with TEFLON® polymer (also an electrical insulator), electrical continuity between adjacent carts **20** may not otherwise be effectively achieved. By electrically connecting the carts **20**, static charges can be bled off from the train, for safety and operational considerations. Thus, the auxiliary cart connector **34** serves two purposes: first, it physically attaches two adjacent conveyor carts **20** and prevents them from becoming completely separated should the hitch mechanism **32** fail; second, it enables electrical continuity among all of the conveyor carts **20** in the train.

Even without the auxiliary connector cable **34**, only the rear end of the trailer frame structure **22** will drop below the conveyor track **12** upon accidental disengagement of the hitches or upon breakage of the hitch mechanism **32**. Therefore, instead of the front end **36a** of the driven fin **36** digging into the floor sides or underlying structures below the conveyor, as is the case with prior art conveyors, the driven fin **36** will simply be dragged with relatively minimal damage should one of the hitches **32** break or become accidentally uncoupled. If an auxiliary connector cable **34** is attached between two adjacent carts **20** that break apart, the connector cable **34** will limit the distance that the rear end of the trailer frame structure **22** will drop, further limiting damage.

Mounted atop the trailer frame base **22** of each conveyor cart **20** is the support **58a**, which supports the carrying tray **40** thereabove. There may be one or more supports **58a**.

In one embodiment, as best seen in FIGS. **3** and **4**, the support structure **58a** may be a generally planar member that lies in the vertical plane parallel to the conveyor line of travel **64**. In one example, the support may include a pivot structure **60** and/or could take on the form of a hinge structure joining together two generally planar support structures, one **52** attached to the tray **40**, and one **58a** extending from the frame base **22**.

As can be seen in the drawings, the tray **40** may be planar or may also include upwardly angled lateral wings **42** to help prevent packages **11** from accidentally falling off the tray **40**. These wings **42** also decrease the angle of the slope created when the tray **40** is tilted, which helps with gentle handling of the packages **11** as they are discharged from the cart **20**.

When a carrying tray **40** reaches a particular destination unloading station **18**, the tilting mechanism **50** tilts the carrying tray **40** to cause a package **11** carried thereon to be discharged into the unloading station **18**. A tilting mechanism **50** is generally mounted on each conveyor cart **20**.

FIG. **5A** shows one embodiment of the tilting mechanism **50** including at least one gear **106a** having at least one cam **110a** for tilting the carrying tray **40** toward at least one side of the conveyor. The tilting mechanism **50** is typically mountably attached to a portion of the cart **20**, usually the support **58a**, and engages with a camway **112a**. The camway **112a** may be at least partially housed within a support **58a**. The cam **110a** may be rotatable around an axis of rotation **104a** between about 0 and about 360 degrees. The cam **112a** may travel to varying degrees around the axis of rotation **104a**, for example, between about 0 and 140 degrees, 0 and 120 degrees, 0 and 90 degrees and/or a combination or other degrees in between.

In another embodiment, the tilting mechanism **50** may further include an extension or camway **112a** or second camway **112b**, a second gear **106b** having a second cam **110b**, wherein the second cam **110b** is rotatable around an axis of rotation **104b** between about 0 and about 360 degrees. The cam **110b** may travel to varying degrees around

the axis of rotation **104b**, for example, between about 0 and 140 degrees, 0 and 120 degrees, 0 and 90 degrees and/or a combination or other degrees in between.

In FIG. 5A, a tiltable support **58a** is shown in a substantially non-tilted position on the axis of tilt **102**. In this position, the support **58a** is supporting the tray **40** in a substantially neutral position. The support **58a** may include one or more camways **112a** and **112b** extending substantially horizontally and/or substantially vertically throughout the mechanism **50**. The cams **110a** and **110b** move within and/or without the camways **112a** and **112b**, respectively, as the gears **106a** and **106b** are rotated around their axis of rotations **104a** and **104b** when movement is activated by a gear drive **114**. As the cams **110a** and **110b** move within the camways **112a** and **112b**, the tiltable support, and thus the supported tray **40**, is tilted around the axis of tilt **102**.

As seen in FIG. 6A, the conveyor cart **20** may also include a tilt sensor **140** for determining the direction of tilt of the tray **40**. The tilt sensor includes switch **144a**. The tilt sensor may be a dual tilt sensor and include switches **144a** and **144b**. The tilt sensor may also include an array of switches. The tilt sensor **140** may be adapted to operate as a direction indicator. The tilt sensor **140** may also or otherwise be adapted to operate as a positioning indicator. The tilt sensor **140** may be configured to sense a reference area **142a/142b** on a corresponding gear **106a/106b**.

The switches **144a** and **144b** may be, by way of example, non-contact sensors that operate in a closed, and alternatively, an open position. As will be recognized by one of skill in the art, a variety of sensors may operate to provide similar feedback about reference areas on one or more gear, however, shown, to provide an example, in FIG. 6A are switches **144a** and **144b** that close upon the presence of a metal reference point **142a** and **142b** and remain open when in the presence of a non-metal reference point **146a** and **146b**.

FIG. 7 shows a cross sectional side view, inter alia, of the cart **20** including the tray **40**, the support **58a**, the gears **106a**, the gear drive **114** and the drive device **115**.

Referring to FIGS. 5A-5E and 6A-6C generally, in operation, the switches provide feedback that may be processed to determine and control the direction of tray tilt and/or the positioning of the tray. In FIG. 5A it can be seen that when the tray **40** (as a result of the support **58a**) is in a neutral position, the cams **110a** and **110b** are at about 0 degrees about the axis of rotation **104a** and **104b**. At the 0 degrees position, both cams **104a** and **104b** are both located inside a substantially vertical portion of the camways **112a** and **112b**. With both cams **112a** and **112b** in this position, the tray is locked in a neutral, mostly horizontal, position. This locked structural positioning serves to keep the tray locked in a neutral position even in the event of power failure or mechanical malfunction and prevents errant and unintended deposition of packages **11**.

When it is desirable for the tray to be tilted, the gear drive **114**, powered by a drive device **115**, may be actuated in a clockwise or counterclockwise direction. If the drive gear **114** actuates in a clockwise direction, then the gears **106a** and **106b** will turn about their axis of rotation **104a** and **104b** in a counter clockwise direction and cause the tray **40** to tilt in the clockwise direction, or same direction as the rotation of the drive gear and vice versa.

In FIG. 6B, the drive gear is shown actuating in a counterclockwise direction and causing the gears **106a** and **106b** to turn about their axis of rotation in an opposite, clockwise direction. As the gears begin to rotate, the associated cams **110a** and **110b** also rotate and move along their respective camways **112a** and **112b**. Movement of the cams

in the camways allows the support to tilt along the pivot axis. Rotation clockwise of the gears causes upward movement of cam **110b** in camway **112b** and downward movement of cam **110a** in camway **112a**. At approximately 45 degrees of rotation, the cam **110b** has reached the peak of camway **112b** while the cam **110a** has begun to exit the internal camway **112a** located within the support **58a**. As can be seen, this configuration allows for significant movement of the cams within the camways prior to instigating tilting of the support **58a** and the tray **40**. When the trays begin to tilt, the tilting mechanism **50** may come under significant load attempting to deposit packages **11**. Applicant has found that allowing the drive gear to ramp up movement prior to experiencing the load during tilt, may significantly increase efficiency and accuracy of the tray tilt. Applicant also recognizes that ramping down movement, for example the drive gear, prior to returning the tray to the neutral position, may contribute to increased efficiency and accuracy of the tray tilt as well.

FIGS. 5C, 5D and 5E show continued clockwise movement of the gears **106a** and **106b** by approximately 90 degrees so that cam **110a** has traveled downward in camway **112a** and proceeded substantially horizontally to exit the internal camway. Cam **110b** originally proceeding upward in its camway, is now directed to move back down the camway and out into an extreme position at approximately 135 degrees of gear rotation allowing for left (or counterclockwise) tilt of the tray **40** to about 45 degrees from its neutral position, adequate for depositing a package **11** carried on the tray **40**. This movement allows the drive gear **114** to ramp down as the tray reaches maximum tilt and the gears **106a** and **106b** approach maximum rotation sufficient to accomplish desired tray tilt. The gears **106a** and **106b** operate in a reverse fashion about the axis of rotation **104a** and **104b** to return the cams to the idle state where the tray **40** is locked in a neutral position.

In the field of sorting conveyors, Applicant has identified a demand for conveyors that can operate more efficiently, deliver goods more effectively and reduce cart and delivery error. The tilting mechanism **50** of Applicant's inventions, functions to reduce acceleration and deceleration load effects on the gears, the gear drive, and gear device. Variables such as velocity and acceleration of the tilting mechanism during delivery and recovery not only affect the ability to deposit the package accurately but also the efficiency of the sorting conveyor **10** in whole. By way of example, management of these variables may be as seen below to accomplish efficient and effective tilt of the tray to substantially forty-five degrees.

TABLE I

## 45 DEGREE P-TILT

Tip profile	500 [Milli sec]				
Tray width	40 inches				
Tilt degrees	45 Degrees				
Radius from pivot	20.49 inches (assume 1" thick tray spacer)				
Arc length	16.09 inches				
Gear rotation [degrees]	Tilt Angle [degrees]	Time [milli sec]	Velocity [in/sec]	Acceleration [in/sec <sup>2</sup> ]	
0	0	0	0.00	0.00	
13.5	0.73	50	6.18	10.30	
27	3.18	100	20.74	24.27	
40.5	7.73	150	38.52	29.63	
54	14.4	200	56.47	29.91	
67.5	22.5	250	68.58	20.18	
81	30.6	300	68.58	0.00	
94.5	37.27	350	56.47	20.18	



## 11

TABLE I-continued

45 DEGREE P-TILT				
108	41.82	400	38.52	29.91
121.5	44.27	450	20.74	29.63
135	45	500	6.18	24.27

Turning to FIGS. 6A-6C, the rotation of the gears may be monitored by the tilt sensor 140 and the information gathered by the tilt sensor and stored or processed by a controller (not shown), the controller, for example being a microprocessor, which is conventional in the art. The controller may also be used to track all packages 11 moving on the conveyor 10 and to automatically signal at the appropriate time when a particular package 11 reaches its destination unloading station or outfeed chute 18. The controller may further be connected, remotely or directly, to other features in the disclosure, such as, the tilting mechanism 50, the tilt sensor 140 and/or the opposed roller motor assembly 210.

The information gathered by the tilt sensor 140 may be used to determine a positioning of the tray 40 and also to direct the rotation of the gears 106a and 106b. Such information is important so that a faulty tilt tray may be quickly detected, errors minimized and the cart fixed.

Typically, in the field of tilt trays, a "home" sensor is used. The home sensor monitors when a tray is in its neutral position and then employs an encoder to track the distance away from home (neutral) that a tray has moved. In the case of a problem, the tray is programmed to return to the home signal and into a neutral position. However, in this scenario, if the "home" sensor is faulty or there is a power outage, then the tray loses its homing beacon and it is unable to determine the positioning of the tray. This is because the home sensor usually does not provide information about which direction the tray is tilted and without a home signal it is unable to right itself because the tray cannot recognize which direction is home.

In operation, applicant's inventions, in contrast, provides a "not home" signal to the tilt sensor 140. A reference area 142a and 142b is provided that is recognized by the switch 144a and 144b as a "home" reading. Other areas are provided 146a and 146b that do not produce a "home" signal to the switches 144a and 144b. By way of example, a metal ledge may be added to portions of the gears 106a and 106b that is detected by non-contact sensors serving as the switches 144a and 144b. The non-contact sensors may be programmed to recognize the metal reference area as a "home" signal so that when the switches are not in contact with the ledge, a "not home" signal is recognized by the switches. As may be recognized by one of skill in the art, other types of switches may recognize differing types of reference areas, and the switches may be programmed alternatively so that the "home" or "not home" signal is associated with the reference area, of which is also considered within the scope of this invention.

In FIG. 6A, the tray is shown in a neutral position. By way of example, the area 142a and 142b may produce a "home" signal as readable by the switches 144a and 144b. The area 146a and 146b of the gears 106a and 106b may produce a "not home" signal as readable by the switches 144a and 144b. In the neutral position as shown in FIG. 6A, the switches 144a and 144b would sense a "home" signal as the distal area of the switches sense reference areas 142a and 142b. As seen in FIG. 6B, when the tray 40 is tilted to the right and the gears 106a and 106b are rotated, the reference area 142a remains detectable by the switch 144a and a

## 12

"home" signal is produced by switch 144a. The reference area 142b is not detectable on gear 106b and the switch 144b produces a "not home" signal.

As in FIG. 6C, when the tray 40 is tilted to the left and the gears 106a and 106b are rotated accordingly, the reference area 142a is not detected by switch 144a and a "not home" signal is generated. The reference area is detectable on gear 106b and the switch 144b produces a "home" signal.

In the dual switch configuration, the tilt sensor detects, operates and directs the rotation of the gears typically as seen in the table below:

TABLE II

Switch 144b	Switch 144a	Reaction
Reference area sensed Home Reading	Reference area sensed Home Reading	Tray recognized in neutral position
Reference area sensed Home Reading	Reference area not sensed	Tray recognized as tilted left. Gear 146a rotates to re-attain "home" reading, so gears 146a and 146b directed to rotate counterclockwise to attain tray neutral position.
Reference area not sensed Not Home Reading	Reference area sensed Home Reading	Tray recognized as tilted right. Gear 146b rotates to re-attain "home" reading, so gears 146a and 146b directed to rotate clockwise to reach tray neutral position.
Reference area not sensed Not Home Reading	Reference area not sensed	Produces error notification and tray shuts down until fixed.
Not Home Reading	Not Home Reading	

The "home"/"not home" detection by the tilt sensor 140 therefore, provides information as to the positioning and direction of tilt, left or right, of the tray, as well as which way the tray needs to be moved to attain a neutral position. It is to be understood that the "home" and "not home" readings may be reversed to accomplish the same outcome. If, by way of example, a tray was tilted to the right and a faulty switch 144a resulted in an errant "not home" signal even though the reference area 142a would normally be sensed by the switch, then two "not home" signals would be produced since sensor 144b would correctly have a "not home signal." Rotating the gear 106a clockwise to try and attain two "home" signals would not correct the problem. Two "not home" signals indicates a problem and could immediately be programmed to shut down the cart and signal for maintenance.

It is to be understood therefore that in one embodiment, cam movement is toward 0 degrees in response to the tilt sensor 140. In configurations further including a second gear having a second cam, each cam movement may respond to the tilt sensor 140 when the tilt sensor monitors a reference area on the gears. The tilt sensor 140 may determine a position of the cams and a direction of tilt of the tray by reading a reference area. At least one cam may actuate the tray toward a neutral position when the sensor determines a not home signal on at least one gear.

The inventions may further include a second gear having at least a second cam and a tiltable support 58a having an incremental titling response to rotation of a first cam 110a and second cam 110b about an axis of rotation 104a and 104b.

The support 58a may attach to or include at least one camway for housing a first cam 110a and a second cam 110b. One of the cams may be housed within a camway within the support 58a and the other cam may be outside of the camway with the support when the cams are rotated sub-

13

stantially between about 25 degrees and about 135 degrees about an axis of rotation of each gear respectively. The support **58a** may be tiltable about between 40 degrees and about 50 degrees around an axis of tilt **102** when a first cam and a second cam **110a** and **110b** are rotated between about 120 degrees and about 140 degrees around the axis of rotation of each gear respectively **104a** and **104b**.

It is also to be understood from the disclosure that rotation of the first cam **110a** in a first direction around an axis or rotation **104a** may tilt the tray in a direction toward one side of the conveyor. Rotation of a second cam **110b** in a second direction around an axis of rotation **104b** may tilt the tray **40** toward an opposite side of the conveyor than the one side. The first cam and the second cam may each rotate about an independent axis of rotation.

Each tray and tilting mechanism may be adapted so that each tray is independently dischargeable from the other trays in the conveyor train.

Additionally, the invention may further include a drive motor for moving the conveyor carts around the track.

The drive motors may include an opposed roller motor assembly **210**, which move the conveyor carts along the conveyor track **12** by the opposed roller motor assembly. The opposed roller motor assembly **210** of the sorter conveyor **10**, which is shown in FIG. **10**, may be a pair of opposed drive roller assemblies **214**, **214'**, which is discussed in more detail in FIGS. **11** and **12**. A driven fin **36**, which is attached to the bottom of each conveyor cart **20**, hangs between the two drive roller assemblies **214**, **214'**.

Composed of semi-rigid, high coefficient aluminum or other conductive metal, the vertical fin **36** preferably has swept-back front **36a** and rear **36b** edges, as shown in FIG. **4**, giving the fin **36** a generally parallelogram shape to reduce damage in the event the fin would contact a structure and to distribute the air gap over the length of the drive rollers to reduce noise and maintain more constant thrust. Specifically, because the gap is angled with respect to the roller, the roller does not hit the gap like a pot hole that is large enough for both wheels to hit at the same time.

Vertically orienting the fin **36** and the opposed roller assembly **210** also reduces problems with maintaining proper spacing between the fin **36** and the drive rollers, because gravity ceases to be a factor as the weight of the live load varies. This results in the fin **36** being easily maintained equidistant between the two drive rollers.

The opposed roller motor assembly **210** ordinarily moves the train of conveyor carts **20** in one direction of travel; however, it can also be reversed if necessary to slow or stop the conveyor.

In one exemplary embodiment, the opposed motor roller assembly **210** of the present inventions is comprised of a pair of support frames **212**, **212'**, a pair of opposed drive roller assemblies **214**, **214'**, and a pair of motor assemblies **216**, **216'**. The second drive roller assembly **214'** provides the opposing surface that exerts pressure in conjunction with the first drive roller **214** on the driven fin **36** of the cart **20**.

As shown in FIGS. **10** and **11**, opposed motor roller assembly **210** and self-tensioning adjustment assembly **300** generally tie movement of the rollers together. For instance, as one roller moves closer, or away, from the driven fin, the opposing roller mirrors the first rollers movement. Thereby, the drive rollers contact the driven fin simultaneously from each side to be self-centering.

Typically, the opposed roller motor assembly **210** may include a cantilevered, drive roller **214** that is connected to first pivot block assembly **330** and second pivot block assembly **330'** to position drive roller **214**. The pair of motor

14

assemblies **216**, **216'** may be mounted on respective pivot block assemblies **330**, **330'** and are connected to the shafts of motor assemblies **216**, **216'**, for instance with drive belts **262**, **262'**. Further, self-tensioning adjustment assembly **300** is generally affixed to base **222** and includes self-tension clamp plate weldment **310** to position the pivot block assemblies about a centered position relative to self-tensioning adjustment assembly **300**.

Self-tensioning adjustment assembly **300** generally maintains opposed motor assembly **210** in perpendicular contact with the driven fin. For instance, self-tensioning adjustment assembly **300** minimizes, or prevents, twisting as the driven fin moves from one drive roller **214** to another. Additionally, self-tensioning adjustment assembly **300** maintains drive roller **214** in a neutral position with respect to driven fin **36** and guide wheels **30**. In this manner, the guide wheels will not comprise the reactive pressure of drive roller **214**.

As shown in FIG. **10**, lever arm **346** is connected to self-tension clamp plate weldment **310** which allow adjustment of the two pivot block assemblies. As illustrated, lever arm **346** may adjust both first pivot block assembly **330** and second pivot block assembly **330'**. In other examples, the first pivot block assembly **330** and second pivot block assembly **330'** may be coupled together with the self-tensioning adjustment assembly **300**, for instance so that movement of each pivot block assembly mirrors movement of the opposing pivot block assembly about a centered position.

FIG. **11** shows one embodiment of an isolated opposed motor roller assembly **210** that is connected to first pivot block assembly **330** and second pivot block assembly **330'**. First pivot block assembly **330** and second pivot block assembly **330'** position drive roller **210** adjacent to one surface of the extended driven fin. A pair of support frames **212** and base **222** are attached to the conveyor track **12** (see e.g. FIG. **1** or FIG. **3** for track **12**) and self-tensioning assembly **300**. Self-tensioning assembly **300** may be connected to base **222** through a weldment, for instance drive clamp plate **310**. Similarly, a second weldment, for instance a drive clamp plate **312** as introduced in FIG. **13**, may secure the first pivot block assembly **330** and/or second pivot block assembly **330'**.

Pivot block assemblies **330**, **330'** may be further connected forward of the first shafts **226**, **226'** with a compression linkage **242**. In this particular embodiment, the first end **244** of compression linkage **242** is connected to pivot block assembly **330**, while the second end **244'** of compression linkage **242** is connected to pivot block assembly **330'**.

FIG. **12** illustrates an isolated opposed motor roller assembly embodiment having second shafts **238**, **238'** which pass through the pivot block assemblies **330**, **330'**. Each pivot block assembly **330**, **330'** includes frictional surfaces **258**, **258'** at the end nearest the pivot block assemblies **330**, **330'** thereby engaging drive belts **262**, **262'** and outer elastomeric surfaces **256**, **256'**. Further, at least one link may be affixed to one of the pivot block assemblies **330**, **330'**. Similarly, a second link may be affixed to the other pivot block assembly **330**, **330'**. For instance, as seen in FIG. **12**, a first link **302** and a second link **304** may be positioned on the corresponding pivot block assemblies **330**, **330'**. In some examples, first link **302** and/or a second link **304** may be motor adjustment links. Other examples include a variety of additional intermittent linkage.

FIG. **13a** shows one embodiment of self-tensioning adjustment assembly **300** and opposed motor roller assembly **210** in an operating position. Self-tensioning adjustment assembly **300** includes first link **302** (see FIG. **13B**), second

15

link **304** and connecting linkage to generally position the pair of pivot block assemblies, i.e. first pivot block assembly **330** and second pivot block assembly **300'**, in alignment with one-another. In yet some other examples, the connecting linkage is a connecting roller link **306**, thereby coupling at least one motor adjustment link to a second link as shown in FIG. **13A**.

FIG. **13b** shows self-tensioning adjustment assembly **300** and opposed motor roller assembly **210** in one embodiment of a second, maintenance position. Here, first link **302**, second link **304** and connecting roller link **306** tie movement of the pivot block assemblies, and associated rollers, together. As shown in this second, maintenance position, each pivot block assembly is positioned adjacent from a centerline and one-another simultaneously in a mirroring fashion, for instance in the direction of the directional arrows indicated in FIG. **13B**. This second position may be beneficial for maintenance, assembly, reassembly or the like.

FIG. **14** illustrates certain isolated elements in self-tensioning adjustment assembly **300**. For instance, self-tensioning adjustment assembly **300** may include first link **302**, second link **304** and connecting roller link **306** to couple the first link **302** second link **304** in a self-centering movement so that movement of each pivot block assembly mirrors movement of the other pivot block assembly.

FIG. **15** further shows isolated elements in self-tensioning adjustment assembly **300**. Here, lever **346** is connected to self-tensioning adjustment assembly **300** and is adapted to adjust pivot block assemblies **330,330'**. For instance, lever **346** mirrors each pivot block assembly about the other pivot block assembly. Self-tensioning clamp plate **310** may support lever **346**. In some examples, self-tensioning clamp plate **310** includes mounting bracket **354** connecting a proximate end of lever **346** to self-tensioning clamp plate **310**. A lever retainer may affix lever **346** to self-tensioning clamp plate **310** to retain a distal handling end of lever **346** in an operating position. As shown in FIG. **15**, coupling arm **344** may connect lever **346** and the connecting roller link **306**. Further, a spring assembly **342** may be positioned and connect coupling arm **344** and connecting roller link **306**. As also shown in FIG. **11**, spring assembly **342** may include spring **350** connected to self-tensioning clamp plate **310** by a spring linkage.

The drive roller assemblies **214, 214'** are generally cylindrical and are made of aluminum or other light-weight alloy. They each have frictional surfaces **258, 258'** at the end nearest the pivot block assemblies **330,330'** for engaging drive belts **262, 262'** and outer elastomeric surfaces **256, 256'** of about 1/4" thickness on most of the remainder of the surface. The frictional surface **258** is preferably a series of circumferential grooves that mate with the drive belt **262**. The drive belt may be a poly v-belt. The outer elastomeric surface is preferably polyurethane with a durometer value (Shore Type A) between about 60 and about 90.

In addition, as discussed above, pairs of LIMB, spaced at 80 feet intervals and operated at 480 volts, draws about 15 amps. This is about 90 watts per foot of sorter for about 70 pounds of thrust. Also, a prior art chain drive would draw about 15 watts per foot of sorter for about 1500 pounds of thrust. To the contrary, the present inventions drive rollers are spaced at 160 feet intervals, operate at 480 volts and draw only about 4 amps. This is only about 12 watts per foot of sorter for about 100 pounds of thrust.

Additionally, it is contemplated that the tilt mechanism **50** and the tilt sensor **140** could be adapted for use in conjunction with a dual axis tipping cart as seen in FIGS. **8, 8a, 9** and **9a**. Mounting a tilt mechanism **50** to a dual axis tipping

16

cart may include mounting the tilt mechanism to accommodate for the angled pivot structure **58**. For dual axis tipping, the pivot axis **62** lies in a vertical plane parallel to the conveyor line of travel, which is shown in the drawings as horizontal line **64**. However, unlike other sorter conveyor tilting carts, the pivot axis **62** of the conveyor cart **20** of the invention is disposed at an angle  $\theta$  to the conveyor line of travel **64** so as to impart two axial components to the tilting of the carrying tray **40**. In this embodiment, the pivot axis **62** is angled downwardly at an angle of approximately 20 to 45 degrees below horizontal in a forward direction. The pivot axis **62** as shown is angled downwardly 30 degrees and the pivot axis **62** intersects a plane occupied by the carrying tray **40** rearward of the center of the tray **40**.

By disposing the pivot axis **62** at a downwardly directed angle  $\theta$  instead of parallel to the conveyor line of travel **64**, two axial components are imparted to the tilting motion of the carrying tray **40**. The first axial component of the tray's tilting motion is lateral tipping on a horizontal axis parallel to the conveyor line of travel **64**. The second axial component of the tray's tilting motion is rotating around a vertical axis **66** perpendicular to the conveyor line of travel. Thus, while the tray only tilts along a single, angled pivot axis **62**, the overall motion of the tray **40** as it tilts includes two axial components.

The tilting motion of the tray may also be described using three-dimensional X, Y, and Z-axis spatial coordinates, as shown in FIG. **9A**, wherein the Y-axis is parallel to the conveyor line of travel **64**, the X-axis extends horizontally perpendicular to the line of travel **64**, and the Z-axis extends vertically perpendicular to the line of travel **64**. In one embodiment, tilting of the tray **40** includes a Y-axis and a Z-axis component, for as shown in FIG. **9A** the pivot axis **62** intersects the Y and Z axes. Specifically and for illustrative purposes only, using the preferred 37.5 degree downward angle  $\theta$  of the pivot axis **62**, it can be appreciated that the ratio of Y-axis motion to Z-axis motion is 60:30. In other words, with a 30 degree angle  $\theta$ , the tray **40** laterally tips somewhat farther than it rotates. If the angle  $\theta$  of the pivot axis **62** is increased to 45 degrees below horizontal, then the tray will tilt and rotate equally.

As shown in FIGS. **8** and **8A**, one effect of this two-axis tilting of the carrying tray **40** is that a side **44b** of the tray that is tilted downwardly also rotates rearwardly relative to the cart **20**. Side **44d** of the tray, which is tilted upwardly, rotates forwardly relative to the cart **20**. The pivot axis **62** may intersect the plane occupied by the tray **40** rear-of-center, the front side **44a** of the tray **40** rotates a greater distance around the vertical axis **66** than the back side **44c** of the tray **40**, upon tilting of the tray **40**. The bisecting center line of the tray **40** rotates farther at its forward end from the horizontal line of travel **64** than at its rearward end. Thus, front side rotation line **48a** follows a longer arc than back side rotation line **48b**. By rearwardly rotating whichever side of the tray **40** is being tilted downwardly, some rearward velocity is imparted to packages **11** as they are being discharged from the cart **20** of the invention into an unloading station **18**. Thus, packages are discharged at a lower velocity relative to the unloading station than the velocity of the train of conveyor carts as a whole. This enables the packages to be discharged into a narrower chute than could be accomplished using a conventional conveyor cart. Additionally, because the packages are slowed down somewhat as they are discharged, there is less potential for damage to occur.

Numerous characteristics and advantages have been set forth in the foregoing description, together with details of structure and function. Many of the novel features are

17

pointed out in the appended claims. The disclosure, however, is illustrative only, and changes may be made in detail, especially in matters of shape, size and arrangement of parts, within the principle of the disclosure, to the full extent indicated by the broad general meaning of the terms in which the general claims are expressed. It is further noted that, as used in this application, the singular forms “a,” “an,” and “the” include plural referents unless expressly and unequivocally limited to one referent.

Certain modifications and improvements will occur to those skilled in the art upon a reading of the foregoing description. It should be understood that all such modifications and improvements have been deleted herein for the sake of conciseness and readability but are properly within the scope of the following claims.

What is claimed:

1. A sorting conveyor for transporting objects and unloading objects at one or more unloading stations adjacent the conveyor, said sorting conveyor comprising:

- (a) a conveyor track;
- (b) a train of conveyor carts connected end-to-end; and
- (c) at least one of said conveyor carts including
  - (i) a frame base for engaging said conveyer track,
  - (ii) a carrying tray for holding the objects,
  - (iii) a support for supporting said carrying tray above said frame base,
  - (iv) a tilting mechanism including at least one gear having at least one cam for tilting said carrying tray toward at least one side of the conveyor, wherein said tilting mechanism includes a second gear wheel having a second cam, said first cam rotating about a first axis of rotation and said second cam rotating about a second axis of rotation, wherein the first axis of rotation and the second axis of rotation are independent and set apart from each other, and
  - (v) a drive motor and a driven member attached to said frame base for moving said conveyor carts around said track, and having an opposed roller motor assembly for moving said conveyor carts on said conveyor track.

2. The apparatus according to claim 1, including a self-tensioning adjustment assembly including (i) at least one motor adjustment link affixed to one of said pivot block assemblies, (ii) a second link affixed to said other pivot block assembly, and (iii) a connecting roller link coupling said at least one motor adjustment link and said second link.

3. The apparatus according to claim 2, wherein said second link is a motor adjustment link.

4. The apparatus according to claim 2, wherein said frame base includes a lower base portion attached to said conveyor track and said self-tensioning adjustment assembly.

5. The apparatus according to claim 4, wherein said self-tensioning adjustment assembly includes a drive clamp plate connected to said lower base portion.

6. The apparatus according to claim 2, including a lever connected to said self-tensioning adjustment assembly and adapted to adjust said pivot block assemblies.

7. The apparatus according to claim 6, wherein said lever is adapted so that movement of each pivot block assembly mirrors movement of the other pivot block assembly.

8. The apparatus according to claim 1, wherein said pivot block assemblies are coupled together and adapted so that movement of each pivot block assembly mirrors movement of the other pivot block assembly.

18

9. The apparatus according to claim 8, wherein said driven member of said frame base comprises a fin moved in the conveyor line of travel by said opposed roller motor assembly.

10. The apparatus according to claim 9, wherein said opposed roller motor assembly and said fin are both vertically oriented beneath said trailer frame base.

11. The apparatus according to claim 9, wherein said fin is generally parallelogram-shaped with rearwardly angled front and rear edges.

12. The apparatus according to claim 8, wherein said drive roller assembly includes a generally cylindrical roller having an outer elastomeric surface for frictionally engaging said driven member.

13. The apparatus according to claim 12, wherein said elastomeric surface is a polyurethane.

14. The apparatus according to claim 13, wherein said polyurethane has a Shore A hardness between about 70 and about 80.

15. In a sorting conveyor for transporting objects and unloading objects at one or more unloading stations adjacent the conveyor, said sorting conveyor having a conveyor track and a train of conveyor carts connected end-to-end, at least one of said conveyor carts comprising:

- (a) a frame base for engaging said conveyer track;
- (b) a carrying tray for holding the objects;
- (c) a support for supporting said carrying tray above said frame base;
- (d) a tilting mechanism including at least one gear wheel having at least one cam for tilting said carrying tray toward at least one side of the conveyor, wherein said tilting mechanism includes a second gear wheel having a second cam, said first cam rotating about a first axis of rotation and said second cam rotating about a second axis of rotation, wherein the first axis of rotation and the second axis of rotation are independent and set apart from each other; and
- (e) a tilt sensor for determining the direction of tilt of said tray.

16. The apparatus according to claim 15, wherein said tilting mechanism is adapted so that each tray is independently dischargeable from said other trays in said conveyor train.

17. The apparatus according to claim 15, wherein said tilt sensor includes a direction indicator.

18. The apparatus according to claim 17, wherein said direction indicator is configured to sense a reference area on said at least one gear.

19. The apparatus according to claim 18, wherein said tilt sensor is a dual sensor.

20. The apparatus according to claim 15, wherein said tilt sensor includes a positioning indicator.

21. The apparatus according to claim 20, wherein said positioning indicator is configured to sense a reference area on said at least one gear.

22. The apparatus according to claim 21, wherein said positioning indicator includes a dual sensor.

23. The apparatus according to claim 15, wherein said at least one cam is rotatable around an axis of rotation of said at least one gear between about 0 degrees and about 360 degrees.

24. The apparatus according to claim 23, wherein said at least one cam travels between about 0 degrees and about 140 degrees around said axis of rotation.

25. The apparatus according to claim 23, wherein said cam moves toward about 0 degrees in response to said tilt sensor.

19

26. The apparatus according to claim 23, wherein rotation of said at least one cam in a first direction around an axis of rotation of said at least one gear tilts said tray in a direction toward one side of said conveyor.

27. The apparatus according to claim 26, wherein rotation of said first cam in a first direction around the first axis of rotation tilts said tray in a direction toward one side of said conveyor and wherein rotation of said second cam in a second direction around the second axis of rotation tilts said tray toward an opposite side of said conveyor than said one side.

28. The apparatus according to claim 26, wherein rotation of said cams in a clockwise or counterclockwise direction is opposite the tilt of said tilt tray in a clockwise or counterclockwise direction.

29. The apparatus according to claim 15, wherein each cam movement responds to said tilt sensor and whereby said tilt sensor monitors a reference area on said gears.

30. The apparatus according to claim 29, wherein at least one cam actuates said tray toward a neutral position when said tilt sensor determines a not home signal on at least one said gear.

31. The apparatus according to claim 15, wherein said support is a tiltable support having an incremental tilting response to rotation of said first and second cams about an axis of rotation.

32. The apparatus according to claim 31, wherein said tiltable support includes at least one camway for housing said first cam and said second cam.

33. The apparatus according to claim 32, wherein one of said cams is housed within a camway within said tiltable support and the other cam is outside of said camway within said tiltable support when said cams are rotated substantially between about 25 degrees and about 135 degrees about an axis of rotation of each gear respectively.

34. The apparatus according to claim 32, wherein said tiltable support tilts about between about 40 degrees and about 50 degrees around the axis of tilt when said first cam and said second cam are rotated between about 120 degrees and about 140 degrees around said axis of rotation of each gear respectively.

35. The apparatus according to claim 32, wherein said cams are rotatable substantially between about 0 degrees and about 25 degrees about an axis of rotation of each gear respectively.

36. The apparatus according to claim 15, wherein said axis of rotation of said first gear and said second gear is between about 0 degrees and about 360 degrees.

20

37. The apparatus according to claim 36, wherein said first cam and said second cam travel between about 0 degrees and 140 degrees around said respective axis of rotation.

38. The apparatus according to claim 37, wherein said first cam rotates about between 0 and 140 degrees around said axis of rotation of said first gear and said second cam rotates about between 0 and 140 degrees around said axis of rotation of said second gear.

39. The apparatus according to claim 15, further including at least one drive for actuating said tilting mechanism.

40. The apparatus according to claim 39, wherein said drive is a gear drive for interacting with at least said first gear.

41. A sorting conveyor for transporting objects and unloading objects at one or more unloading stations adjacent the conveyor, said sorting conveyor comprising:

- (a) a conveyor track;
- (b) a train of conveyor carts connected end-to-end;
- (c) at least one of said conveyor carts including
  - (i) a frame base for engaging said conveyor track,
  - (ii) a carrying tray for holding the objects,
  - (iii) a support for supporting said carrying tray above said frame base,
  - (iv) a tilting mechanism including at least one gear having at least one cam for tilting said carrying tray toward at least one side of the conveyor, wherein said tilting mechanism includes a second gear wheel having a second cam, said first cam rotating about a first axis of rotation and said second cam rotating about a second axis of rotation, wherein the first axis of rotation and the second axis of rotation are independent and set apart from each other, and
  - (v) a tilt sensor for determining the direction of tilt of said tray; and
- (d) a drive motor and a driven member attached to said frame base for moving said conveyor carts around said track, and wherein said drive motor further includes an opposed roller motor assembly for moving said conveyor carts on said conveyor track, said opposed roller motor assembly including a cantilevered, drive roller connected to one pivot block assembly and another pivot block assembly adapted for positioning said drive roller, wherein said pivot block assemblies are coupled together and adapted so that movement of each pivot block assembly mirrors movement of the other pivot block assembly, and wherein said pivot block assemblies are coupled together.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 9,422,119 B1  
APPLICATION NO. : 14/330611  
DATED : August 23, 2016  
INVENTOR(S) : Fortenbery et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

In Column 2, Line 33, after the word one, “the” should be deleted

In Column 10, Line 66, 56.47 should be “5647”

In Column 10, Line 66, 20.18 should be “-20.18”

In Column 10, Line 67, Table 1 Acceleration [in sec<sup>2</sup>], 20.18 should be “-20.18”

In Column 11, Lines 4, 5 & 6 of Table I -continued; 29.01 should be “-29.91”; 29.63 should be “-29.63”; 24.27 should be “-24.27”

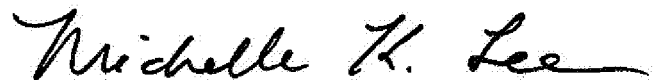
In Column 12, Line 60, titling should be “tilting”

In Column 15, Line 3, 300' should be “330”

In Column 15, Line 15, one-anther should be “one another”

In Column 15, Line 55, LIMB should be “LIMs”

Signed and Sealed this  
Thirty-first Day of January, 2017

A handwritten signature in black ink, reading "Michelle K. Lee". The signature is fluid and cursive, with the first letters of each name being capitalized and prominent.

Michelle K. Lee  
*Director of the United States Patent and Trademark Office*